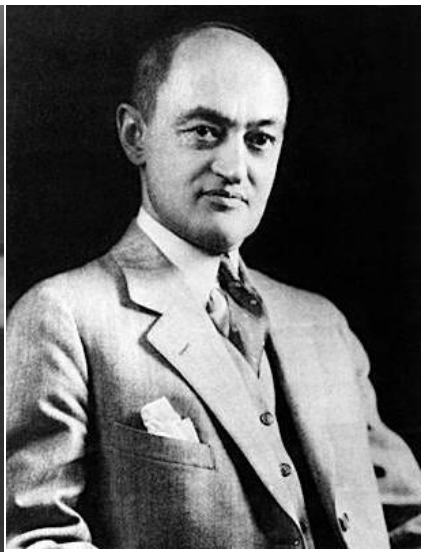
A World of Systems in Christopher Freeman's Research Programme

Tracing the System Approach to Capitalist Evolution and

Social Economics in the Spirit of Joseph Schumpeter

MA - TIK Thesis

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Abstract

The system approach developed by Christopher Freeman can arguably be fruitfully applied to explain and understand the systemic interdependencies of technology, economics, and social change, a framework deduced from Joseph Schumpeter. This thesis is therefore concerned with investigating Christopher Freeman's research programme and assesses it in detail and in relation to Schumpeter's notion of a "broad kind of economics", namely Social Economics. It presents central books and journal articles written by Freeman, and analyses especially the evolution of his system approach to capitalist evolution. The assessment is done in the spirit of Schumpeter in the sense that parallels are drawn between Freeman's theories and propositions and what we have termed Schumpeter's Social Economics.

The thesis traces the evolution of the system approach along four assumed features; that the National System of Innovations is deduced form the idea of the R&D system identified in "The Economic of Industrial Innovation" (1974). The second evolutionary feature is the connection between the development of technology systems and techno-economic paradigms, as well as a connection between these two systems and the national system of innovation. The third feature is the connection between techno-economic paradigms and the long wave pattern in world economic development. Finally, the fourth feature assume that all the above systems interact and is merged into the Theory of 'Reasoned History' presented in Freeman's last book "As Time Goes By" (2001).

The thesis concludes that there has been a significant evolution of a system approach in Freeman's research programme along the proposed features, and that he developed the ideas and propositions set forth by Schumpeter by extending the empirical evidence both supporting and refuting Schumpeter's theories. As such Freeman has contributed to the development of Schumpeter's intellectual legacy by defining new concepts, theorems and propositions, and new frames of interpretation and understanding, thus establishing a dialectical relationship between new real historical data and a progressing theoretical field. The thesis also reveals a relative compatibility between the two kinds of Social Economics.

Keywords: Christopher Freeman, Economic Development, Joseph Schumpeter, National Systems of Innovation, 'Reasoned History', Social Economics, Techno-Economic Paradigms

Foreword and Acknowledgments

When I started my master studies at the Centre for Technology, Innovation and Culture (TIK), it was in pursuit of a more holistic and comprehensible approach to understanding the process of economic growth and development. This thesis can therefore be considered a temporary culmination of my pursuit. Alas, it is far from covering all relevant and interesting aspects of this complex phenomenon in depth, due to both time and space limitations. As such it entails a great curiosity and motivation for further investigations.

Initially I wanted to write a thesis assessing the evolution of the neo-Schumpeterian literature on economic growth and development. A natural outset was to read the works of Christopher Freeman, by many recognised as a leading scholar in innovation studies. This led me, by encouragement from my supervisor, to narrow my study to concerning only Freeman's contributions. With this approach I got to go in depth in Freeman's research and understand his theories on a more profound level. The goal of this process was not primarily the end product, i.e. a completed thesis, but rather the *process* itself, the challenges implied in this sort of engagement, and a deeper understanding of Freeman's works. Whether I succeeded or not in my endeavour is however left to the reader to decide.

I did by no means complete this project on my own. There are several people deserving a many grateful thanks. First of all I would like to express my gratitude towards my supervisor, Jan Fagerberg, for insightful comments and criticism, and early encouragement to undertake this project. I owe much to his motivating remarks and seemingly infinite knowledge. I must also thank my student colleagues at TIK, Sindre Horseby, Tina Næss and Mads Dahl Gjefsen, and also my friends Tor E. Simonsen and Petter Lindgren (on Skype from Japan) for proofreading and useful remarks during the past year. Also the TIK-centre deserves thanks for providing a motivating and pleasant milieu. My family, of course, have offered great support in every possible meaning of the word. To them I owe everything.

However, the sole responsibility for the quality of the thesis rests on me, and any remaining errors or faults are mine, and mine alone.

Good reading. Morten Fosaas, Oslo, May 2010

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List of Abbreviations

D&D – Design and Development
GERD – Gross Expenditure on Research and Development
GDP – Gross Domestic Product
GSCC – Google Scholar Citation Count
NIESR – National Institute of Economic and Social Research
NSI – National Systems of Innovation
OECD – Organization for Economic Cooperation and Development
R&D – Research and Development
Sappho – Scientific Activity Predictor from Patterns with Heuristic Origins
S&T – Science and Technology
SPRU – Science Policy Research Unit, University of Sussex UK
TNC – Transnational Corporations
WWII – World War II

Book Abbreviations

EII – The Economics of Industrial Innovation 1974

UTI – Unemployment and Technical Innovation; A Study of Long Waves and Economic Development 1982

TIIC – Technological Infrastructure and International Competitiveness 1982/2004

TPEP – Technology Policy and Economic Performance; Lessons from Japan 1987

TGB – As Time Goes By; From the Industrial Revolution to the Information Revolution 2001

"In the world of computers and space travel,
it is unnecessary to belabour the importance
of technological innovation. Whether like the
sociologist, Marcuse, or the novelist,
Simone de Beauvoir, we see technology
primarily as a means of human enslavement
and destruction, or whether, like Adam Smith,
we see it primarily as a liberating Promethean force,
we are all involved in its advance.
However much we might wish to, we cannot
escape its impact on our daily lives,
nor the moral, social and economic dilemmas
with which it confronts us. We may curse it or bless it,
but we cannot ignore it."[1]

[1] From the introduction of Freeman (1974) "The Economics of Industrial Innovation".

1 Part One: By Way of an Introduction

1.1 Introduction and Contextualisation of Thesis Subject

The last ten to fifteen years have witnessed an increasing concern for the environment (some are even speaking of a climate crisis), and major instabilities in the global economic and financial system. These changes have also introduced an increasing interest in broadening the field of economics and bringing other social sciences back into the discipline (i.e. incorporating sociology, history, human geography etc. in economic analysis). We have learned from history that crises imply revolution and change, both in science (Kuhn 1970) and in society (see e.g. Schumpeter (1942) and Perez (2002)). The present situation, the so-called climate crisis and the shock to the world's economic and financial system in 2001 and 2008 can be viewed as crises in, or at the very least major challenges to, the economic, political, scientific and technological systems of the world.

Now, how are we able to grasp the complexity of these systems and their interaction? And how can we understand the diversity, the dynamics and the outcomes of such systemic crises or challenges? Founded upon this outset this thesis is concerned with how the works of Christopher Freeman[2] (1921- d.d.), an English historically-oriented economist, deal with complex systemic interactions. His works are primarily concerned with the different *subsystems* of society and their interaction, especially with emphasis on the economic system and the role of innovation in economic development. Freeman identifies these subsystems as *the history of economics; politics; culture; technology; and science*, (not necessarily in that ranking order) as presented in his co-authored work "As Time Goes By" (Freeman and Louçã 2001).

As such, one can say that Freeman's contributions bear similarities with Schumpeter's so-called '(scientific) economics', an economic science assessing social and economic changes as interaction of the different constituent subsystems of society, i.e. a "broad kind of economics". In "History of Economic Analysis" Schumpeter (1954:21) introduces this notion

[2] See Appendix for a stylised biography of Freeman.

of '(scientific) economics', which he in German terms Sozialökonomie[3] (translated to Social Economics[4]), a term mainly advocated by Max Weber (see e.g. (Weber 1914)). What Schumpeter (1954), essentially described was an economic science made up of the sum of economic, historical, statistical, and sociological techniques and the results they produce. This, which we will call Social Economics, differs greatly from the modern orthodox economics, and especially so called 'pure' economics advocated by the neo-classical school, which offer little willingness to take into account other than strictly economic factors in explaining economic change and development. The concern of bringing social perspectives into economics and the broad approach, as asserted by Schumpeter, is, as we shall learn, evident in Freeman's writings. It is therefore natural to ask how Freeman introduces these social perspectives and broad views, as well as how his ideas resonate with Schumpeter's notion of Social Economics.

In a paper published in *Society* titled "*How Does One Study Social Sciences?"*, perhaps less known than some of his other writings, Schumpeter stated that "individual social sciences...did not arise through the logical division of some originally unified realm of knowledge; they arose by chance...from some particular problem or method." (J. A. Schumpeter 1910/2003) cited in (Sloth Andersen 2009:330). From this perspective social sciences should be seen as an evolving structure, constantly undergoing an evolutionary process, and constantly being challenged by new problems and needs for new knowledge. New scientific fields or specialisations within or across disciplines emerge all the time in response to problems that arise and the need for new knowledge to solve these problems (Fagerberg and Sapprasert 2010). These needs also bring about the establishment of specialised, and often cross-disciplinary, research institutions designed to tackle contemporary societal problems. Freeman was the first director of such a specialised research unit, namely the cross-disciplinary Science Policy Research Unit (SPRU) at the University of Sussex established in 1966. Here he engaged in analysis of contemporary societal challenges such as how science and technology policy could enhance economic performance and the problems of technical unemployment. Here he also took command of the famous Project Sappho, a multidisciplinary research project which included researchers from engineering, economics,

[3] According to Swedberg (1995), Schumpeter used this term for the first time in a chapter on economic history in Max Weber's *Grundriss der Sozialökonomie* [Foundations of Social Economics] (1914). The chapter was called *Epochen der Dogmen- und Methodengeschichte* [Economic Doctrine and Method] (Schumpeter, 1914) and can be considered a draft of a later publication by Schumpeter under the same title.

[4] However, we must keep in mind that the term is translated from German, entailing some etymological challenges, and therefore apply it with care.

physics, economic history, and chemistry (Rothwell et al. 1974; Sussex 1972). This study in many ways laid the foundation for Freeman's approach to industrial innovation portrayed in his 1974 book, "The Economics of Industrial Innovation". With this in mind we turn to the purpose of this project.

1.2 Research Question

Freeman states that the idea of the five subsystems of society (cf. above) presented in "As Time Goes By" (henceforth TGB), was a result of his collaboration with Francisco Louçã in 2001 (Freeman, 2008:239). There are, however, reasons to suspect that Freeman developed the conception of a system approach to understanding economic development at an even earlier stage. Even though these early conceptions are not as explicitly stated, nor as elaborate and complete as his latest version, the relevance still stands. These reasons will reveal themselves throughout this thesis, as we take a journey through the works of Freeman, so as to trace the evolution of the system approach to understanding social and economic development[5]. However, as we assume there has been an evolution of this system approach we get a brief introduction here. Already in his first book in 1974 "The Economics of Industrial Innovation", henceforth EII, Freeman presented the notion of a Research and Development (R&D) system. Further, during the 1980s, he introduced the ideas of a national system of innovation (much similar to the R&D system) and what he termed technology systems (clusters of related technical and managerial innovations). These ideas further led Freeman to adopt (from Carlota Perez) the idea of techno-economic paradigms which formed a new explanation of the so-called long wave pattern in economic development. These efforts culminated in many ways in TGB in 2001, and the Theory of 'Reasoned History', a term Freeman adopted form Schumpeter (see e.g. Schumpeter's "The Explanation of the Business Cycle"(1927) where Schumpeter introduced this concept).

As implied above, this thesis is concerned with assessing Freeman's research programme, in light of Schumpeter's Social Economics, and in specific trace the evolution of the system approach to a more holistic understanding of economic development, with technical change and innovation at its core. By research programme in this context is meant exactly: *a body of research conducted by an individual, a combination of individuals, or by an entire field of*

[5] This must not, however, be confused with the World Systems approach developed by e.g. Wallerstein (1974), and Hopkins and Wallerstein (1982).

science, dedicated to explaining a defined set of phenomena. The definition of science is here not strictly limited to natural sciences as in the Popper-Lakatos tradition but also include social sciences and humanities. As such we identify Freeman's research programme as his efforts to explain the interactions between scientific, technological, economic, and social and political phenomena and their co-evolution. Further we need to define what is meant by *system approach*. A system is constituted by a variety of elements and their interrelation. A system approach is thereby defined as an approach conceptually embedded in such interrelations. The system approach in Freeman's works is as such the interrelations between science, technology, economy, politics and culture. The overlying *research question* can thereby be formulated:

> *How is the system approach to economic and social change developed in Freeman's research programme, and how does it relate to Schumpeter's Social Economics?*

Based on the order in which the different systems are presented in Freeman's works we should suspect certain connections between the systems and their evolution. We can formulate some features along which we assume the systems to evolve. They will also serve us good in concluding this project, as well as bringing some clarity to the structure of Part Two. These features will be referred to throughout Part Two as well as section *3.1.1 Features of the System Evolution.* Based on the brief introduction to the suspicion of an evolution of the system approach above we extract four distinct features. First, we can assume that there is a connection between the R&D system which is developed in EII and the concept of national systems of innovation (**F1**). Second, we can assume a connection between the development of technology systems and techno-economic paradigms, as well as a connection between these two systems and the national system of innovation (**F2**). Third, we can assume a connection between techno-economic paradigms and the long wave pattern in world economic development (**F3**). Fourth, and last, we can assume a connection between all the above systems and the Theory of 'Reasoned History' (**F4**).

The reason to engage in such a research project is twofold. First, as presented above, Freeman's theoretical contributions are suggested to offer assistance in coping with analysis of complex relations in world economic development and crises in different systems of society. Second, to my knowing, there exist no such assessments of Freeman's research. There exist some publications of selected essays, e.g. "The Economics of Hope" (1992) and the more recent "Systems of Innovation" (2008). These does not, however, asses Freeman's

research programme as a whole, but focus on particular aspects of his research, e.g. the national systems of innovation. One reason for this may be that some of Freeman's theories are fairly new, and have just gained momentum and status as a comprehensive approach to economic and social development. In fact the whole field of innovation studies is approaching maturity and has undergone a significant development the past few decades, with the emergence of specialised journals such as Research Policy, Journal of Evolutionary Economics, Structural Change and economic Dynamics (Fagerberg and Sapprasert 2010). It can be argued that time is ripe for such an assessment, both considering the state of today's society (cf. climate crisis and economic instability) and the maturity of Freeman's research.

1.3 Methodical Approach

As our main objective is to assess Freeman's research programme the methodical approach is basically limited to a literature review. The methodical approach is made up by essentially two parts. First, it consists of an empirical part, namely collecting, selecting, and reading the literature written by Freeman[6]. The second part is a comparative and critical operation, i.e. the comparison of Freeman's writings with alternative approaches and connecting it to the concepts of what we called Social Economics. Through this approach the reading of Freeman's works are not conducted in the 'usual' way, but in light of understanding his ideas on the totality of how social and economic life interact, and as such the focus of attention is on the underlying conceptions in his writings. This approach will allow us to trace how the early research and writings connects to the more mature and developed ideas presented in TGB (2001). Therefore, TGB was read first, in order to grasp the full idea of Freeman's system approach. Then the rest of the literature was addressed chronologically, according to when it was written and/or published in order to connect the ideological and practical considerations, basically in light of the exposition in TGB. Hence, the search for a research programme is organised in a retrospective manner. The main argument for this approach is to enable a clear view of what to look for in Freeman's texts so as to be able to give a plausible answer to the research question.

[6] In order for the reader to get familiar with some of the texts on which this thesis is based, a briefly commented list of what is considered to be Freeman's most important works, which also serves as the core empirical basis, is presented in the Appendix at the back.

The core literature is essentially made up of a selection of Freeman's books. These are "The Economics of Industrial innovation" (EII) 1974, "Unemployment and Technical Innovation" (henceforth UTI) 1982, "Technology policy and Economic Performance" (henceforth TPEP) 1987, and "As Time Goes By" (TGB) 2001. There exists a gap in the core literature in the 1990s. This gap is covered by e.g. journal articles, "Economics of Technical Change" (1994), and "The National System of Innovation in a Historical Perspective" (1995) especially, and an essay collection ("The Economics of Hope" 1992), founding a complementary literature base.

In selecting the primary literature for this thesis a rather simple principle was applied. First of all, the books which Freeman had written and co-authored were selected. Anthologies and edited-only volumes were excluded. The reason for this was to limit the primary literature to Freeman's core contributions, and to avoid disturbance in the empirics, i.e. to avoid attributing other authors' opinions to Freeman. Secondly, articles and papers were selected by topic and content, so as to filter out the literature not concerning our research question. Further, it should be noted that the first book, namely EII is the only one of the books sole-authored by Freeman, which has been published in more than one edition. Three editions of this book have been published in 1974, 1982 and 1997 (with Luc Soete) respectively. We focus only on the first edition, as the later editions are highly likely to be influenced by Freeman's further findings, and in this way could cause disturbance in the empirics. Finally, when referring to certain arguments or sections/chapters in Freeman's texts the page/chapter numbers are included in the reference so as to make it easier for the reader to validate the suggested interpretations.

Since we are to assess Freeman's works in the light of Schumpeter's Social Economics, we need to get familiar with this concept. This will also help clarify and make the research question more precise. Therefore, an introduction to his Social Economics is presented.

1.3.1 An Interpretation of Schumpeter's Social Economics

In comparing Freeman to Schumpeter's Social Economics we need to know exactly what this is and how we can use it as frame of reference for our inquiry. First we make use of a wide and general definition. It will also serve as an out set for comparing Freeman and Schumpeter in Part Three.

Swedberg (1995) assesses the conception of Social Economics, in relation to what he calls 'socioeconomics'[7]. He goes on to define 'socioeconomics' as (1995:531); "a general view of the economic process, whose main characteristics is that this process can ultimately be understood only as an expression of an *interaction between economic and social elements.*" The intension of the term 'socioeconomics' as presented here, can serve as a starting point for understanding Schumpeter's Social Economics. This wide definition can be seen as the overlying rationale, and normative principle in Social Economics, i.e. a broad kind of economics analysing economic phenomena using other than strictly economic measures and methods. Further, it substantiates the notion that:

> The social process is really one indivisible whole. Out of its great stream the classifying hand of the investigator artificially extracts economic facts. The designation of a fact as economic already involves abstraction, the first of the many forced upon us by the technical conditions of mentally copying reality. A fact is never exclusively or purely economic; other – and often more important – aspects always exists. (J. A. Schumpeter 1934:3).

The inclusion of a variety of social elements is needed to make economic analysis broader and thus *more realistic*. This understanding of economic facts also imply an understanding of the economy not as a system isolated from society, as conceived in orthodox economics. Rather it conceives the economic system as part of the social systems in which society is organised. Therefore, understanding the social superstructure and the social reality of which economics is a central part is crucial to understand economic development. While some less obvious etymological differences between 'socioeconomics' and Social Economics exist, they present no relevant obstacle for our interpretation.

As presented, Schumpeter termed economic history, statistics, economic theory, and economic sociology, and the results these tools of analysis produce, Social Economics. Therefore we need to know what these categories contain, i.e. we need to define their boundaries, their interdependency and their contact surfaces. We draw on Schumpeter's assessment in interpreting and defining the kind of Social Economics we want to serve as the reference of our inquiry. Thus the following is deduced from Schumpeter (1954:12-22) in light of the above citation.

[7] This, of course, is not a term free of problems in application. As part of terminology in economic sociology, and hence subject to interpretation it is arguably not a straightforward preferable term. However, we shall not read into it anything more than what is assessed by Swedberg's (1995) interpretation of the term, which form the basis for our understanding of 'socioeconomics' and its relation to Schumpeter's Social Economics/'(scientific) economics'.

Economic History in Schumpeter's framework is important due to the fact that economic events take place in historical time, thus requiring historical analysis. Also, these economic events are not isolated to any form of economic sphere or realm. Rather, they are embedded in the social reality surrounding them, effectively and in essence being part of an overlying social structure. In this sense economic history, in Schumpeter's assessment of it, concerns not only isolated economic events, but also the history of the reality in which these events take place. This is not to say that economic history is a history of everything, a total history. It is merely to point to the fact that the social reality affecting and being affected by economic events must be accounted for in economic history.

The second part of Schumpeter's Social Economics is *statistics*. He states that: "It stands to reason that for economics, statistics, that is, the statistical figures and series of figures must be of vital importance" (1954:13). In this lies the assumption that any good economist should be so well acquainted with statistics that he or she understands completely how the methods work, how the figures and tables are compiled and also their epistemological underpinnings. In order to have these understandings the importance of knowing the field of statistics stands solid.

Then there is *economic theory*. By theory in Schumpeter's framework is meant exactly two things. First and less important is theory as explanatory hypotheses. Such hypotheses are necessary to provide a framework for the investigation of certain phenomena. But such hypotheses are by no means the sole constitutor of economics. The second, and more important, understanding of theory in this context is the conceptualisation and classification of various mechanisms that exists in economic life, i.e. *how* actors (individuals, firms, countries) behave in the economy.

The last part of this Social Economics is *economic sociology*. Whereas economic theory is concerned with explaining economic behaviour within the social framework, economic sociology deals with the parts of this framework which are of special relevance to the economy, e.g. institutions, politics, law, culture, etc. As such it determines the conditions for economic behaviour, i.e. *why* actors behave as they do. Thus it is closely related to economic history. However, this economic sociology is not meant to give a detailed account of the

surroundings it should describe. Rather it should help to make what Schumpeter called "a sort of generalised or typified or stylised economic history" (1954:20).

We should bear these four categories in mind when assessing Freeman's research programme throughout Part Two of the thesis as we in the concluding part will make a comparison between the Social Economics of Schumpeter, as described above, and Freeman's Social Economics which we shall assess in the end of Part two.

1.3.2 Structure of the Thesis

The thesis is organised in three main parts. They are the introduction and contextualisation above (Part One), a presentation of Freeman's works and analysis of these (Part Two) and a concluding part (Part Three). Each part is consisting of a number of chapters (bold headings) and sections (italic headings). In addition an appendix is placed at the back.

The purpose of the structure of the thesis is to assist the methodical approach and help answer the research question, as well as to build a stringent argument through presenting Freeman's writings in a semi-chronological order and according to research topic. This order of presentation also illuminates the different levels of analysis in Freeman's writings, i.e. it portrays the level of aggregation. These levels are identified as the firm/industry level, national (policy) level, and the international/global level. In the beginning of Part Two a definition and taxonomy of innovations is presented, in order to create a categorical framework for organising theories and propositions concerning innovations proposed by Freeman. Further, the approaches to capitalism by Schumpeter and Freeman, as well as a comparison of these are presented. This is to set the stage for our understanding of the purpose of the system approach. As we go along throughout Part Two, the different clues supporting the hypothesis of an early idea and application of a system approach are presented at the beginning of each chapter, after which follows an exposition on the main working mechanisms, implications and alternative views of Freeman's systems. This will be done for each system concept, i.e. the R&D system, the national system of innovation, technological systems, techno-economic paradigms, and finally the Theory of 'Reasoned History'. This will constitute Part Two of the thesis. This is done to enable a presentation of the indications and evidence of the evolution of the system approach and Freeman's Social Economics.

The last part (Part Three) of the thesis is mostly concerned with gathering any loose threads from the preceding chapters and of course with pointing to evidence confirming or invalidating the proposed overlying research question. It will trace the evolution of the system approach in Freeman's works and compare his Social Economics to that of Schumpeter. As such Part Three is concerned with summing up the findings in Part Two. It will also offer some suggestion for further research on the subject of Freeman's theoretical contributions as well as the whole field of innovation studies.

In the final part of the thesis there is an appendix which, as noted, contains an annotated list of Freeman's main contributions and also a stylised facts biography of Freeman.

2 Part Two: Assessing Freeman's Works

In order to fully grasp the complexity in Freeman's writings we need a thorough presentation of his research and theoretical propositions relevant to our objective. First of all we need to understand the role of innovation, how innovations are made and their implications in the various systems of economy, policy and society, as innovations and technical change is placed at the core of explaining economic and social development in Freeman's works. Therefore we are introduced to a definition and taxonomy of innovations to form a general and overlying understanding of what innovations are and what changes different innovations induce. Then we get familiar with the process of making innovations, their social structures and the context in which they emerge, namely capitalism. The presentation is then taken to another level, where we are introduced to the role of innovation in a national perspective, i.e. how it affects the competitive performance and prospects of economic growth at the national level and in the world economy. These perspectives are assessed in light of the development and interaction between the national system of innovation, technology systems, techno-economic paradigms, and finally the Theory of 'Reasoned History'.

The idea behind this exposition is to show how the different systems, which are so crucial in Freeman's approach, are developed and how they interact on different levels and across industries and countries, and how these systems introduce other than strictly 'economic' measures in understanding economic growth and development. In speaking of economic growth and development, we are not necessarily applying the terms, especially the latter, in a conventional manner. The interpretative framework is deduced from Dosi et al. (1994) and Nelson (1994). The term *economic growth* here refers to exploitation of economic dynamics where things (economic measures) simply get bigger or smaller, or stay the same. This growth is measured by taking a snapshot of reality at certain points in time. Comparing these measures will give an indication whether these measures have grown, declined or stayed the same for a given time period. As such economic growth is comparative statics. *Economic development* on the other hand includes a *qualitative change* over time. Thus it should be analysed to explain the underlying working mechanisms of economic growth, exploring the reasons for economic development, i.e. the *how* and *why*. As it takes place over time, it must be dependent on history and the accumulated knowledge constituting the premises for growth.

Economic development in this sense is obviously not confined to regard the economic state of less developed countries, as perhaps more commonly conceived.

2.1 A Definition and Taxonomy of Innovation

Innovations are not always easily defined and comprehended as they are results of complex interactions and can take various forms which are not all measurable. It is therefore of great help in understanding their complex nature to construct a taxonomy of innovations. The motivation for this taxonomy is twofold: first, innovations manifest themselves in various forms, not all materialistic, i.e. they can take form of organisational or managerial structures and systems, and are thereby sometimes not immediately tangible; second, their implications on society and economy may call for different levels of analysis. By possessing a categorical or taxonomic conceptualisation of what innovations are, how they manifest themselves and what are the implications of various forms of innovation, we are better prepared to understand the exposition in this part of the thesis (Part Two).

A reasonable outset for defining innovations is presented in Schumpeter's "Capitalism, Socialism and Democracy" (J. A. Schumpeter 1942), where he classifies innovations as new products, new technology, utilisation of new inputs in production, exploitation of new markets, new types of organisations and management styles etc. We can interpret this classification of innovations as having a second layer of meaning, and the key word is knowledge, or rather application of knowledge. Innovation is understood as application of new knowledge in new or old areas, and application of old knowledge in new areas. Innovation is thereby not necessarily intimately connected to novel ideas or inventions. Therefore innovation has a strong sense of application (or commercialisation), and the notion of novelty in innovation must therefore be in terms of application of knowledge. By way of this outset for understanding innovation, it can subsequently be categorised into different kinds of innovations and their impacts. In the next section a taxonomy of innovations based on Freeman and Perez (1988) is presented.

2.1.1 A Taxonomy of Innovations

A rather well known distinction between innovations is the *product-process distinction.* The former is related to innovation leading to new products, the latter to innovation altering the process of making products, i.e. production. Product innovation is relatively straight forward.

It is about creating new products. Process innovation can result in cheaper fabrication, higher quality etc. of existing products. Thus, the distinction is made between the *results* of any given innovation. The following taxonomy is exclusively based on Freeman and Perez (Freeman and Perez 1988:45-47). Their taxonomy is based on empirical research conducted at the Science Policy Research Unit (SPRU).

(i) Incremental innovations

These types of innovations are often the result, not of deliberate R&D efforts and activities, but rather of inventions and improvements by those directly involved in the production process, and are thus results of learning processes such as 'learning by doing' and 'learning by using'. Such incremental innovations have impacts on productivity and efficiency of machinery and other production capital. They are proven to occur more or less continuously, but at different rates at different times and in different industries in different countries. The rate, the time, and the place of the occurrence of such innovations are dependent upon a combination of demand pressures, socio-cultural factors, technological opportunities and trajectories. They are related to scaling up of production and improvement in quality of products and services in a great variety of applications. They are also often related to process innovations.

(ii) Radical innovations

Radical innovations are mainly the result of deliberate R&D efforts and activities in enterprises and university laboratories, and are in essence discontinuous over time. Such innovations are unevenly distributed over both time and industries. The essential impact of these innovations is their capability as springboards for the growth of new industries. The result is often the emergence of new products, and thus new markets and industries. These changes are also associated with all forms of innovations, i.e. product innovations, process innovations and organisational innovations. In an isolated industry, not acting in clusters such as the semi-conductor cluster of Silicon Valley, they do not bring about any aggregated economic or social effects, though they do induce structural changes in the industry of their origin.

(iii) Changes of 'technology systems'

Some combinations of innovations have a more far-reaching impact than radical innovations, as the changes in technology are capable of affecting several branches of the economy, as well as giving rise to entirely new industries and sectors. Organisational and managerial innovations combined with incremental and radical innovations leads to these changes. It is as much the novelty of the *combination* of these innovations as the novelty of the innovations themselves that induce these far reaching changes. Emergence of clusters of economically and technologically interrelated industries is a common result of such changes. As they are results of radical innovations, these changes encompass structural changes.

(iv) Changes in 'techno-economic paradigms'

Even more far-reaching and revolutionising are the changes in 'techno-economic paradigms', also called 'technological revolutions'. These changes have major influences on the behaviour and structure of the whole economy, carrying with it a number of clusters made up of radical and incremental innovations, and may embody several 'technological systems'. Further, successive changes in these techno-economic paradigms are also believed to drive the long wave pattern in world economic development, as asserted by Kondratieff. The specific dynamics of such changes are dealt with in more detail in later sections (*2.5.2 Techno-Economic Paradigms* and *2.6 Long Waves in World Economic Development*).

2.2 The Capitalist System and the Social Structure of Innovations

This chapter examines the resonance between Freeman's and Schumpeter's understandings of innovation and the capitalist system. Both Schumpeter's and Freeman's research on economic and social development is essentially limited to the age of capitalism, from the industrial revolution in the late 1700s and onwards. Therefore we need to understand the two approaches to what is believed to drive the capitalist engine and how we should understand the capitalist dynamics. We get introduced to Schumpeter's and Freeman's approaches, as well as the social structure of innovations below.

2.2.1 Freeman and Schumpeter; Two Conceptions of the Working of Capitalism

Let us begin with examining how Schumpeter and Freeman understand the capitalist system. As implied in the interpretation of Schumpeter's Social Economics in section *1.3.1*, one would expect a broad definition of capitalism. However, he understood capitalism as an "economic system characterised by private property, by production for a market and by the phenomena of credit" (Schumpeter 1928:362), the last phenomena which distinguish capitalism from other historical, or possible, economic systems. This economic system is however not isolated from, but rather influenced by political, cultural, and economic institutions and structures. As such he emphasised the need for a broad kind of economics in order to understand the capitalist dynamics. The approach of Freeman is somewhat different from Schumpeter's. The development of the five subsystems presented in the introduction suggests a broad approach to understanding capitalism not as an isolated economic system working independent of the social superstructure, but rather as a semi-autonomous part of this social superstructure, affecting and getting affected by the history of politics, science, technology, and culture. This demarcation of capitalism as a wider social system, contrary to a strictly economic system, necessarily calls for a broad approach including other social sciences to understand its working mechanisms. It follows from the above that *capitalist evolution must be understood as the economic and social changes taking place within the capitalist system*. Even though the demarcation of capitalism is different between Freeman and Schumpeter, capitalist evolution is nevertheless influenced by changes in the systems surrounding it in both approaches. We shall learn that Freeman and Schumpeter have somewhat different conceptions of what drives capitalism and how we can cope with the capitalist dynamics.

Although Schumpeter stressed the importance of historical and social analysis in understanding economic development, he also greatly admired the general equilibrium approaches which emerged in the late 1800s and gained momentum in the time he was writing "Business Cycles", in the 1920s- and 30s (Fagerberg 2003). However, he explicitly rejected these systems of equilibrium. Based on the historical argument in dealing with economics, demanding a *dynamic economic system*, Schumpeter wrote:

> Development ultimately consists of the disturbance of an existing static equilibrium, and it does not have a tendency to return to a previous or to any equilibrium...On the contrary, an equilibrium only exists in a static economy. (J. A. Schumpeter 1912:489)[8] cited in (Swedberg 1995:533).

Further he also describes the failing of static economic theories to understand economic development as a dynamic and cyclical phenomenon:

> The description of the interaction of which makes up the theory of economic equilibrium, do not contain anything out of which a tendency towards cyclical movement could automatically arise (J. A. Schumpeter 1927:290)

Freeman however, never questions the dynamics of capitalism. The discontinuous nature of radical innovations driving clusters of booming industries (cf. technology systems in the taxonomy above) and the dimension of qualitative change in innovations, demand a certain dynamic nature of capitalism, contrary to the static equilibrium models of neo-classical economics. The conception of the economy being governed by dynamic forces seems to be beyond doubt in Freeman's approach. The basis for his approach may well be inspired by Schumpeter, but it is also quite different from Schumpeter.

The discontinuous nature of radical innovations seems to be crucial for both Freeman (cf. the taxonomy above) and Schumpeter. Schumpeter emphasised this point: "But innovations would be powerless to produce booms, if they went on continuously in time" (1927:297). They also seem to agree on understanding innovations as a product of social evolution. Freeman actually explicitly states his agreement with Schumpeter:

> The social mechanism of innovation is one of survival of the fittest. ....The notion of perfect knowledge of the technology or of the market is utterly remote from the reality of economic principles, and the dynamic nature of capitalism held by Schumpeter. (Freeman 1974:167)

The connection between economic growth and innovations is stressed in both approaches. The clustering of radical innovation forming booming clusters, ultimately driving the capitalist cycle presented in "Business Cycles" (J. A. Schumpeter 1939) is one example from Schumpeter's account. This relates in many ways to what is termed technology systems in Freeman's taxonomy presented in section *2.1.1*. These are believed to be constituted by

[8] The first German edition of this book contained a seventh chapter which was excluded from later editions. This was done because Schumpeter felt the focus of the preceding chapter was overshadowed of this last seventh chapter, which got a lot of attention based on its relatively controversial suggestions. Therefore the number of pages in this first edition is larger than the normal 255 pages in the case of the English translation from 1934. (Swedberg 1995). For a complete translation of this chapter see Backhaus (2002).

clusters of radical and incremental innovations leading to booming industries and sectors. There is however not a mono-causal relationship between booming clusters of radical innovations and the long wave pattern in world economic development in Schumpeter's approach. He believed that no single radical innovation or cluster of innovations could be specifically linked to a long wave (Fagerberg 2003; J. A. Schumpeter 1939). This is also the case for Freeman's conception of technology systems as presented in the taxonomy, which could be seen as a parallel to Schumpeter's clusters of radical innovations. Freeman assigns techno-economic paradigms the role of constituting such long waves, as techno-economic paradigms are wider and more pervasive than just a cluster of radical innovations, as well as containing the required institutional and social changes. Herein lies also the problem of determining a causal direction between capitalism and innovation; does innovation drive capitalism or does capitalism drive innovation? The essence of this question is whether change comes from within or from outside. Certainly the fierce competition of capitalist market economies radically changes the *external conditions* for economic activity forcing actors to innovate. This does not, however, mean that innovation is a capitalistic phenomenon. Advances in knowledge and technology (essential for innovation) have long before the age of capitalism been essential for both economic and social progress (the invention of the wheel). Therefore, innovation should not be considered a product of capitalism in Freeman's (or Schumpeter's) approach, but as increasingly important due to the competitive pressures of the capitalist system. As such one would expect the rate of change also to increase due to the rapid production and diffusion of innovations, i.e. capitalist evolution grows increasingly faster.

In placing innovation, the way he does, at the core of explanatory variables in his framework Freeman, beyond all doubt, is largely inspired by Schumpeter. The idea of novelty in application of knowledge, i.e. innovation, leading to great profit possibilities taking form of temporary monopoly-like market situations is held as one of the main ideas (though not the only incentive) of the motivation for innovation. In one of his papers written at NIESR he states (brackets added):

> For a country which is ahead in producing or using these types of equipment [electronic capital goods] will be the first to realise the economies which are clearly possible, and will enjoy a significant competitive advantage as a result. (Freeman 1965:42)

This clearly has a Schumpeterian flavour to it: the idea of competitive advantage on the basis of technological superiority. This idea of technical superiority is also reflected in the theory of the firm presented in chapter **2.3** and the national system of innovation discussed in chapter **2.4**. In comparison with the famous and widely used Schumpeter citation one detects striking similarities (brackets added):

> In capitalist reality as distinguished from its textbook picture, it is not that kind of (price and quantum) competition which counts but the competition from the new commodity, the new technology, the new sources of supply, the new type of organization. ….This kind of competition strikes not at the margins of profits and the outputs of the existing firms but at their foundations and their very lives.
> (J. A. Schumpeter 1942:84)

The implication of this conception of capitalist competition attributes innovation great importance in achieving competitive advantages, rather than prices and quantum. This does not, however, completely undermine the role of prices in capitalist competition. It merely puts a much less than conventional emphasis on it. This approach also has effects different from those in orthodox theory reaching out into the realm of international trade. These effects are dealt with in the section on *'Catching up' and the Role of the National System of Innovation in Trade Performance*.

Innovation is undoubtedly attributed a central role in capitalist evolution (the social and economic changes which takes place within the capitalist system) in both Schumpeter's and Freeman's approaches. Therefore we need to understand how innovations occur. In understanding the making of innovations in Freeman's approach we can once again turn to Schumpeter. His idea of the 'entrepreneur', the hero in the economy putting ideas into novel commercial application, plays a prominent role in Freeman's research on the occurrence and development of e.g. the cotton and iron industries (Freeman and Louçã 2001 - Chapter 5). However the role of the 'entrepreneur' is not sufficient to describe all innovations to Freeman. By the establishment of large transnational corporations (TNC), due in part to monopoly power in certain industries and as the possibilities of expanding on a global scale were enabled through new means of transport and communications, R&D efforts leading to innovation were bureaucratised in large corporate laboratories, and along came the government interest in R&D activities, partly motivated by military research in the inter-war era (Freeman 1974:24-32). The new model of innovation consisted of a combination of inventor-entrepreneurs such as Thomas Edison or Guglielmo Marconi, and large scale corporate and government R&D laboratories such as Standard Oil, General Motors, IG

Farben, and the American Department of Defence Research. Freeman also assigns the 'entrepreneur' a specific role in the process of innovation:

> the critical role of the 'entrepreneur'(whatever individual or combination of individuals fulfils this role) is to 'match' the technology with the market, i.e. to understand the user requirements better than competitive attempts, and to ensure that adequate resources are available for development and launch. (Freeman 1974:191)

The role of this 'entrepreneur' is constructed along the same lines as e.g. Penrose (1959), Barna (1962) and the work of Schumpeter (1934, 1939) on the theory of the firm. It is important to acknowledge that the essential task of the 'entrepreneur' in this understanding of him is the 'matching' of invention and demand, whatever the origination of the idea or invention, be it an ingenious scientist in his home laboratory or large corporate or public R&D programmes, or even a fruitful combination of the two.

The two suggestions of the making of innovation, the 'entrepreneur' and the bureaucratised and corporate R&D departments, are often referred to as Schumpeter's Mark I and Mark II models of innovation. This, however, is a somewhat suggestive labelling, which imply that they are two different models operating at different times. Freeman evidently does not apply these models working independent of each other at different times. Nor is there any reason to believe this was the purpose of Schumpeter's description of the making of innovations. Although the innovative activities in the beginning of the industrial revolution in the 1700s were dominated by such 'entrepreneurs' or 'inventor entrepreneurs', and thereby supporting the notion of a so-called Mark I model, by the end of the 19th century the two kinds of innovative activity were intertwined and functioned in combination (Freeman 1995:8-10). Freeman argues for the combining, or co-existence, of the two models being a result of the fact that a larger part of product and process innovations was based on understanding theoretical and scientific principles and as a result, more and more research conducted in universities and corporate R&D laboratories became significant for innovations (Freeman 1974:162-164). In this understanding also lies an implicit notion of innovations being contingent upon other factors external to the innovator's environment e.g. the possibilities of transportation and communication as above. This may be different institutional conditions retarding or facilitating the innovation process, acting as a selection mechanism. We shall however get more familiar with such conditions in the next section.

The role of organisations, institutions, and firms in bringing out innovations, in contrast to the Schumpeterian entrepreneur, the hero in the economy, calls for an increased role of government policies. The bureaucratisation and professionalization of R&D activities and science is far more important in Freeman's approach than it is in Schumpeter's. This may be due to the changing characteristics of the R&D processes, especially after the Second World War, when the bureaucratisation and professionalization was constantly increasing and even more important as technology became increasingly connected to advances in science (cf. previous paragraph). This obviously opens up for a crucial role of government policies in bringing out innovations, as governments in large fund and prioritise the fundamental scientific research conducted in universities. But government policies are not only crucial in the funding of research. They are also crucial in facilitating the diffusion of innovations. Included in the focus of policies, the aspect of understanding and facilitating the diffusion of innovations also is far greater in Freeman's approach than in Schumpeter's. We shall however learn more about such policies in later chapters (**2.3** and **2.4**). Whereas Schumpeter devoted little or no attention to politics and policy in his economic theories, Freeman devotes much attention to these perspectives. This is evident in e.g. EII's chapter 9 "Aspects of Public Policy for Innovation", in UTI chapter 10.1 "The Role of Technology Policy", and in TPEP's chapter 5 "Technology Policies in the UK", as well as various journal articles concerning this topic, e.g. Part One in the essay collection "The Economics of Hope" (1992) pp. 1-73 and "Technological Infrastructure and International Competitiveness" (1982/2004).

2.2.2 Innovation and the Fate of Capitalism

The placing of innovation as the main driver of capitalist competition and dynamism has certain implications on the nature of capitalism and the capitalist fate. Schumpeter had a rather dark prediction of the future of capitalism. This prediction is however twofold. In 1928 in his paper "The Instability of Capitalism" he states that:

> Capitalism, whilst economically stable, and even gaining in stability, creates, by rationalizing the human mind, a mentality and a style of life incompatible with its own fundamental conditions, motives and social institutions, and will be changed, although not by economic necessity and probably even at some sacrifice of economic welfare, into an order of things which it will be merely a matter of taste and terminology to call Socialism or not. (J. A. Schumpeter 1928)

This is a concerned disbelief in the future of the capitalist system itself and its working mechanisms and undermining of its own fundamental conditions. However, later, in

"Capitalism, Socialism and Democracy" (J. A. Schumpeter 1942), he pointed to the bureaucratisation of R&D as the main cause of capitalism eventually resulting in socialism, or merely an order of things similar to socialism, due to the loss of dynamism in capitalism when innovation as the driving force is bureaucratised. Freeman has no such dismal perception of the capitalist fate. Nonetheless, he makes an interesting point concerning the role of the government in the process of innovation. In his study of the electronic capital goods industries he states that: "Governments are necessarily involved in this R&D as sponsors, as performers, as source of funds, and as purchasers of finished equipment" (Freeman 1965:42).

The role of government interaction is quite clearly expressed, an opinion which will be stressed throughout the thesis, and which Freeman upholds in his subsequent research. The role of the government is in Freeman's work substantially different and also much greater, than in orthodox economics, especially in neo-classical theory under so-called 'laissez faire' conditions. Whether this increased government interaction is to be labelled socialism along the lines Schumpeter draws in the above citation is a question which requires analysis on a deeper level, and will not, however interesting, be dealt with here. Another point is more important in this respect, namely that the driving force of capitalism, i.e. innovation, is facilitated not only by private monopoly-profit seeking 'entrepreneurs' but also by the government interest in technology and its propensity to invest, thus providing vital venture capital. The discrepancy in the view of consequences of government intervention and bureaucratisation of R&D is quite clear. Both Schumpeter and Freeman recognise the fact that R&D is increasingly bureaucratised, as such they agree on the premises but differ in their conclusions. Further, Freeman not only considers the specialisation and bureaucratisation of R&D as a crucial aspect of the continuing of bringing forth innovations, he even celebrates the capitalist institutions and their ability to select and diffuse important innovations throughout the economy, thus substantiating the capitalist system:

> In fact the capacity to generate a wide variety of potential new products, services and organizations and to confront them on a trial and error basis with these various selection processes over a prolonged period is probably the strongest evolutionary advantage of the capitalist institutions themselves (Freeman 1992:122)

As such, the future of capitalism is relatively safe within Freeman's framework, and the capitalist system is even considered to be the one which most effectively produces the crucial innovations on which it itself relies.

The two previous sections support the claim that Freeman, although considerably influenced by Schumpeter and having extensively borrowed from Schumpeter's central ideas and propositions, is not strictly Schumpeterian in his approach. This is apparent in the different conceptions of capitalism. In Freeman's approach capitalism is driven by organisations and institutions, rather than heroic individuals, and he assigns public policy an explicit role in governing the capitalist dynamics. This, and the predictions of the future of capitalism, is evidently different from Schumpeter.

2.2.3 The Role of Selection Environments

In considering Freeman's work as in the tradition of neo-Schumpeterian or evolutionary economics we need to be careful, and distinguish between the concepts *social evolution* and the theory of biological evolution. As expressed by Marx (1867/1999) the difference between the worst architects and the best bees is that the architects erects first of all in the imagination what is subsequently constructed in reality. This refers to the difference between social and biological evolution in the interaction of selection environment and the mutations which emerge and survive. In essence innovation is a *social process*, and capitalist dynamics driven by innovations is a process of social evolution. Such processes as innovation simply do not occur within the 'blind watchmaker' or neo-Darwinian biological evolution, in capacity of being the result of social processes, which are not included in a biological framework (Freeman 1992:126-127). As such the differences in selection environments in social and biological evolution are of crucial importance. As we shall see, some of the selection environments in social evolution, such as the institutional environment, are socially constructed. In this way human consciousness and choice is a determining feature of social evolution and its selection mechanisms-and environments. We can hardly overstress the distinctions between social and biological evolution. However the most important ones have been illuminated. And as Freeman states, although biological analogies are made only to exemplify the working mechanisms in evolutionary economics:

> ...it is important not to be carried away by evolutionary analogies and to mistake the analogy for the reality (as often occurs with computer simulation models which have the similar heuristic value)...It would be as dangerous for economics to take over wholesale the models of biology as it was to take too much of equilibrium models derived from physics. (Freeman 1992:123)

Therefore it must be with this warning in mind one interprets the role of selection environments. The main purpose of the selection environment is to impose sequences of

rewards and punishments of failure of adaption of innovations. This is the process of adaption not only to market demand, but also to other social institutions, such as conventions, laws and financial institutions. Freeman (1992:124-126) operates with three different selection environments:

(i) the natural environment
(ii) the built environment
(iii) the institutional environment

The Natural Environment

The sheer scale of human population and economic activities means that whatever the forms of social organisation, interactions between the natural environment and human technology will be increasingly important. The natural environment poses constraints on what is possible, for instance regarding the depletion of fossil fuels, sustainable population etc. However, new technologies such as space-technology and bio-technology may help relax some of these natural constraints, but will never be sufficient to abolish them. As Freeman states: "Catastrophic events in the natural environment can at any time introduce a new set of penalties, constraints and priorities" (Freeman 1992:123). This relates in specific to the point made in the introduction on how natural conditions, i.e. a climate crisis, can dictate priorities and possibilities in innovation selection processes.

The Built Environment

The built environment is constituted by the capital, or real capital, produced to facilitate production and technical development, such as physical infrastructure, machines, buildings, railways etc, which to a large extent shows the same characteristics as the natural environment in cases of constraints and possibilities. However, there is another dimension to the built environment which distinguishes it from the natural one. This are the constraints physical assets may lay on investment in new capital by means of cost, profitability and social acceptability, and not only in physical terms (Freeman 1992:125). Even so, this long lived existing capital may also encourage new investment in capital, as the old capital deteriorate and depreciate, stimulating technical change. This would be the working mechanism of the Kondratieff and Kuznets cycles, through creative destruction and structural changes. The investment in capital embodies new technologies, as in so-called 'putty-clay' models of economic growth and structural change (see e.g. (Biørn and Frenger 1992; Johansen 1959)),

and the considerations of location, scale, durability and cost of physical capital powerfully affects these investment decisions.

The Institutional Environment

The institutional environment is constituted by previously accumulated experience in research and science along with the formal institutions of finance and other organisations (cf. 'mental' capital). Thus it includes both formal and informal institutions. This feature gives it a special role in selection of innovations. Therefore the institutional selection environment must be understood as working at different levels. Undoubtedly, the realm of scientifically conceivable is wider than the realm of the technically feasible, which in turn is far wider than the economically profitable, which in turn is wider than the socially acceptable (Freeman 1992:127; Perez 1985). So the institutional environment encompasses all these selection mechanisms and can be seen as the reason for capitalisms success in bringing out innovations. This is due to the capitalist institutions constituting the main advantage of capitalism in bringing out innovations compared to other social and economic systems. In Freeman's words:

> Capitalist institutions have so far proved the most effective in human history in stimulating a flow of technical and organizational innovations and diffusing them through the production system (Freeman 1992:126)

Therefore the institutional selection environment is of particular interest when dealing with capitalist development. Also, within each of these selection environments one can identify certain selection mechanisms. These could be e.g. the working of new technologies, R&D projects, and market success, i.e. demand, profitability, market size, cost consideration etc.

Understanding the systemic context and the various levels and various forms in which innovations occur and take form, as well as understanding the social structure of these innovations is crucial to properly assess Freeman's works. Therefore we now turn to his research, presenting the books and journals constituting our empirical base, and analyse these in light of the research question presented in chapter **1.2**.

2.3 The R&D System, Firm Behaviour and Innovation Incentives

> Yet not to innovate is to die.

The implications of this statement (Freeman 1974:256) are not to be mistaken. Innovation is essential to the survival of firms competing in a market. It is all about gaining competitive superiority and reaping super-profits made possible by innovation. In this part is presented central themes of an evolutionary theory of the firm and its relation to innovation. First is presented what one can regard as an early conception of the system approach, namely the R&D system proposed in EII (1974). Second, some different innovation strategies firms can adopt and the role of project estimation and uncertainty in innovation are presented. Then follows an exposition on the so-called the 'Schumpeterian hypothesis', the relation between firm size and innovation, and finally differences in innovation activity in different branches and industries. These latter points may at first glance seem irrelevant for the matter at hand. However, the reason to devote so much attention to this topic is essentially because it is deduced from the idea of an *R&D system* and its importance in surviving in competition, and not least in securing progression in economic development. Hence, it is of significant consequence for the innovation approach. In addition, it offers a relatively unconventional theory of the firm compared to orthodox economics. It introduces new competitive measures along the lines presented earlier, and even new principles for the industrial organisation of markets. Also, this exposition on the theory of the firm compiles some of the features of the built- and institutional selection environments. Further, it gives insight into the working mechanisms in bringing out innovations on the firm level. Understanding factors and determinants of innovation on all levels of analysis[9] is crucial to grasp the complexity of the system approach developed throughout Freeman's works. Last but not least, the exposition in this chapter is essentially based on Freeman's 1974 book on the economics of industrial innovation, EII. This happens to be the most cited of his works (Google Scholar Citation Count – GSCC 4178). Not only is it his most influential book, it is also his first major contribution to the theory of innovation. Hence, it deserves some attention.

[9] The levels of analysis we are operating with is, as stated in the introduction, the firm/industry level, the national (policy) level, and the international level.

2.3.1 An Early Conception of a System Approach

Already when at the National Institute for Economic and Social Research (NIESR) in the 1960s, Freeman formed a notion of a Research and Development (R&D) system in the chemical process plant and electronic components industries (Freeman 1965, 1968). He identified and stressed the importance of the interaction between various institutions, e.g. government funding, legislation, education system, R&D departments etc., in being successful in these (knowledge intensive) industries. Moreover, in his first major work on innovation and technical change Freeman assessed the crucial importance of innovation and the link to a systemic approach to understand its coming into being, not only on the firm level and in certain industries, but even at a broader and higher level. Freeman adopted the wide definition of knowledge industries from Machlup (1962) considering them as covering the "generating, disseminating, and applying advances in technology" (Freeman 1974:20). And as he so cogently point out on the role of the R&D system in the complex of 'knowledge industries':

> But this Research and Development system is at the heart of the whole complex, for in contemporary society it originates a large proportion of the *new* and *improved* materials, processes and systems, which are the ultimate source of economic advance. This is not to underestimate the importance of *dissemination* of knowledge through the education system, industrial training, the mass media, information services and other measures. Nor is it to deny the obvious fact that in the short run rapid progress may be made simply by the application of the existing stock of knowledge. It is only to assert the fundamental point that for any given technique of production, transport or distribution, there are long-run limitations on the growth of productivity, which are technologically determined. No amount of improvement in education and quality of labour force, no greater efforts by mass media, no economies of scale or structural changes, no improvements in management or in government administration could in themselves ultimately transcend the technical limitations of candle-power as a means of illumination, of wind as a source of energy, or iron as an engineering material, or of horses as a means of transport. Without technological innovation, economic progress would cease in the long-run and in this sense we are justified in regarding it as primary, although operating in close association with other factors... In the most fundamental sense the winning of the new knowledge is the basis of human civilization. (Freeman 1974:20-21)

The R&D system of which he speaks can be interpreted along two dimensions. First of all it can be seen as an early conception of what he later termed National Systems of Innovation, see e.g. (1982/2004, 1987), which we shall assess in more detail in chapter **2.4**. The other dimension of this term is the rather explicit causal relation- and direction inherent in it. It assesses R&D as the main source and contributor to technical change, or innovation, which is

essential to long-run economic growth. Hence, technical innovations are conceived as driven forth by R&D (which in essence is knowledge contingent upon progress in science).

The importance of knowledge in creating new materials, products, processes and their impact, is also explicitly expressed as the "the ultimate source of economic advance". This notion of the importance of applied knowledge, i.e. innovations, founded the basis for Freeman's theories on firm level innovation and economic development. Therefore we shall be acquainted with what firms can do to produce innovations and thereby gain competitive advantages, and exploit the potential of the R&D system.

2.3.2 Firm Innovation Strategies

There obviously exists a wide range of innovation strategies for firms striving to keep going in the fierce competitive markets of capitalism and to exploit new technological and market possibilities. These strategies must be seen as possible responses to changing external pressures. Hence they are as much competitive strategies as they are innovation strategies. Freeman (1974:259-281) confines these alternatives into four strategy categories:

(i) Offensive strategies

(ii) Defensive strategies

(iii) Imitative and dependent strategies

(iv) Traditional and opportunist strategies

These four types of innovation strategies should be considered as spectres of possibilities, and not as a set of purely defined strategies consisting in only one form at a time. Even though some firms follow strategies recognisably, we must have in mind that they may change from one strategy to another at different times and in different markets and sectors in which they compete, and eclectic strategies are highly likely to be applied. However these categories bring simplicity to the framework. We shall not devote much attention to these strategies, and will leave out categories (iii) and (iv). We do this because these two latter categories serve no explicit purpose in understanding the role of the R&D system presented above as they predict little or no R&D efforts by firms (Freeman 1974:271-281). As such we focus on the two former categories, namely the offensive and defensive strategies, which are adopted by firms aspiring to be in the very front of technological advance and exploit the potential in new

technologies and market possibilities. As such they are presented in the way they appear in EII.

First, let us consider the offensive strategy. The aim of such a strategy is in Freeman's approach to be ahead of business opponents, in terms of technological leadership and competitive advantages. The achievement of this goal is often dependent on being the first to introduce new products and create new markets. This is often related to high R&D intensity, and fundamental research is often conducted 'in-house'. Also a high degree of patent protection is typical, as the firm is in critical need of high profits to cover the high R&D expenditures and the inevitable failures in innovation processes. In orthodox economics such high and costly in-house R&D efforts are derided as 'white elephants'. The argument rest on the assumption of fundamental research being available in scientific journals etc, and should be conducted in universities and other research institutions. In Freeman's framework this argument breaks down due to its failure to understand information processing in research correctly. The hypothesis which holds that success in innovation is correlated with high in-house fundamental R&D is supported by a number of empirical studies, e.g. the Sappho project at SPRU (Freeman 1974:259-266). Although not crucial for an offensive innovation strategy, in-house fundamental R&D proves to be valuable means of access to new and old external knowledge (i.e. from outside the firm such as universities and independent R&D laboratories), and a source of new ideas within the firm. This approach is dependent upon a long-run perspective, as the lead time of innovations could amount to not only months but also years.

However, most firms are not believed to adopt such a high risk innovation strategy, with high uncertainties and low guarantees for success. Even firms adopting this strategy are not likely to exercise it continuously over time. Most firms are satisfied with reaping monopoly profits in one market at a time, resting on their laurels, thus abandoning the offensive strategy. One alternative strategy is then, according to Freeman, the defensive strategy. The aim of this strategy is not, like the offensive one, to be first with new products and processes, but to be able to keep up with the pace of change. It provides the ability to learn from others' early innovation mistakes and improve existing designs. In order to do so the firms must have the technical capability and strength to do so. Therefore this strategy by no means implies the absence of R&D. Rather the purpose of this strategy is to not be left behind in the quagmire. This is also connected to the risk perspective. A defensive strategy incurs less risk than an

offensive one, and also provides an opportunity of learning from others' mistakes. Further, the adoption of this strategy may according to Freeman (1974:266-270) be a result of the lack of connections to fundamental research, which require high in-house efforts or special relations to research bases. May a firm's *forte* be in e.g. marketing or production engineering, a defensive strategy is suitable. Patents are as important in defensive strategies as in offensive. They do, however, play a rather different role. As for an offensive innovator patents are crucial to uphold a monopoly position, for a defensive innovator they act as bargaining chips to weaken such a monopoly. In the case of an offensive innovator opening up new markets with new products, thus initially taking a monopoly position, the defensive innovator with patented inventions relating to the new innovation, can break this monopoly power through bargaining. The long run perspective applies both here, and for the offensive strategy.

These strategies relate to the idea of absorptive capacity developed by Cohen and Levinthal (1990). This theory has over the years gained some momentum and has established itself as a highly regarded theory of the importance of inter alia R&D in firms to be able to keep up with technical change. They argue, as does Freeman, that the firm's R&D efforts not only increase the firm's internal knowledge base and opportunity to innovate, but also that the by-product of these efforts is an enhanced capacity to gain and implement external knowledge. Thus the R&D system is of crucial importance for firms possessing the necessary absorptive capacity to keep up with technical change in the social reality of competition in which firms conduct their business.

2.3.3 The Role of Governments and Animal Spirits in Innovation Projects

The majority of innovation projects are not completed, i.e. they are terminated before commercial launch. This is due to constantly ongoing project evaluations. Some projects are terminated at the idea stage, some are further explored but shelved, and some are carried through all the way to commercial launch. This development of an innovation project must be taken into consideration when determining if an innovation is a success or a failure. Even at the final stage, the commercial launch, the rate of failure is high, but would be even higher if one counted in all those projects terminated or shelved on earlier stages. According to Freeman (1974:222-225) this is due to uncertainty and the continuous project evaluations which complicates finding a formula ensuring success as a considerable amount of success variables, recognisable ex post, are not controllable ex ante. This is especially true in a

market, where the behaviour of your opponents is unpredictable (in contrast to a neoclassical full information framework).

In accordance to Freeman we should understand the innovation process as containing a substantial amount of uncertainty. This uncertainty can, however, take different characters. The two most important kinds to consider here are technical and economic, or market, uncertainty. They differ in many respects, but the most fundamental distinctions are between their measurability and insurability (Freeman 1974:225-226). Varying degrees of uncertainty is found, reflecting the type of innovation activity being conducted. Technical uncertainty is not measurable as is economic uncertainty, and thus more difficult to insure. However, this uncertainty in innovation can give strong incentives for firms not to undertake the more radical type of product innovation, but to concentrate their industrial R&D on defensive imitative innovation projects, product differentiation, and process innovation. Further, a distinction is made between in-house process innovation and open market product innovation. This is important as to what kind of risk, or rather uncertainty, which is involved in innovation projects. Product innovation involves both technical and market uncertainty, whereas process innovation only involves technical uncertainty. In assuming most firms are somewhat risk averse, or at least not risk lovers, an important role for government funding and financing of e.g. basic research is laid out. As governments are not met with the same requirements regarding cost over-runs and profitability, one would assume most radical (and highly uncertain) innovations to be carried out by governments and public R&D laboratories and research programmes. Further, "government expenditures....should be concentrated on applied research and early experimental development. It is in the area of fundamental research and fundamental invention that the economic for public finance and public laboratories is overwhelming" (Freeman 1974:286).

However, not only governments undertake radical innovation projects. In the explanation of why this is the case Freeman adopts the notion of so-called 'animal spirits' from Keynes (1936). The role of the 'animal spirit' is essential to Freeman (1974:235-237) in carrying out certain innovation projects. These 'animal spirits' are risk lovers, such types who set out to conquer Mount Everest or the South Pole. Any rational and risk averse individual would never commit to the risk involved in such expeditions. The same holds for undertaking radical innovation projects. Animal spirited actors are driven by the urge to succeed and to be the best without regard for any mathematically calculated risk assessment on investment in

innovation. Thus a handful of such 'animal spirited' civil or private firms and entrepreneurs are essential to maintain the flow of radical innovation which are so important to the industrial dynamics and economic development. This may be seen as a parallel to the Schumpeterian novel entrepreneur.

Freeman also considers other incentives for firms to engage in high risk innovation projects besides the 'animal spirits' (Freeman 1974:237-238). The first and perhaps most obvious is seen in firms struggling to survive in the market. They are often impelled to gamble on high risk innovation due to a threat to their existence as they got nothing to lose, leaving high risk innovation projects their last resort. Large firms can also accept some high risk innovation projects as a part of their project portfolio as in a 'risk spreading' mechanism, where they have more certain success in other low risk projects. This is impossible for small firms as they do not possess the required amount of resources. Also in large firms where innovation projects are not closely subject to or controlled by any formal project selection system, high risk projects are found to be undertaken. This lack of formality allows scientists and developers to follow their intuition and gut feeling rather than the objective mathematical calculations of success and risk in innovation projects. A final, and also typical, incentive is government sponsored projects, willing to take high risks in innovation due to either over-optimistic estimates on future returns, or (more sinister) out of necessity as urgent national needs in cases of war and natural disasters, or as deliberate social or science policy. The need for positive returns are less, at least formally, required and negative returns (in terms of failure) do not impose a direct threat to public decision makers, as it does to firms.

It has been suggested above that large firms may have advantages in innovation processes, and even, stronger incentives to undertake innovation projects involving high risk often related to radical innovations. Therefore we turn to Freeman's findings regarding the Schumpeterian Hypothesis.

2.3.4 The Schumpeterian Hypothesis Revisited

This section will give an introduction to the so-called 'Schumpeterian hypothesis' which suggests that large firms in imperfect markets (monopolistic or oligopolistic competition) are more conducive to innovation then smaller firms in highly competitive markets. This is a long standing and well tested hypothesis. Alas, the dimension of market structure is often left out,

for obvious practical reasons. Market structure is not an easily quantifiable variable, perhaps impossible to satisfactorily operationalise in quantitative analysis, resulting in the hypothesis being reduced to concern only the correlation between firm size and innovative activity. Further it does not offer any indications whether large firms innovate more because they are large, or whether they are large because they innovate more, i.e. no causal direction between firm size and innovative activity is established. It is however relevant to illuminate the impacts of firm size on industrial innovation as described by Freeman. His first major book on innovation, EII (Freeman 1974), is especially concerned with identifying an R&D system, or pattern, in certain industries. In such an effort the Schumpeterian hypothesis is clearly of importance.

Is there any significant relation between a firm's size and its output of innovations? Freeman (1974:199-221) finds that there is a tendency for larger firms to innovate more than small firms or private entrepreneurs. However, this is dependent on industry, i.e. in some industries large amounts of resources are necessary to do research (chemistry), in others not (mechanical). Additionally, large firms will have an advantage in commercialising inventions, making them innovations, and small firms may have advantages in early stage development of less expensive radical innovations, and large firms in incremental and scaling up of innovations. Also some innovations demand vast amounts of components (Apollo Space Program), or large sums of money, and are out of reach of small firms. Large firms also have an advantage in risky projects. They have better margins in projects involving uncertainty. Smaller firms are, however, more flexible and less path dependent, have better concentration of resources and internal communication, which may be their greatest advantages. The findings are however less conclusive in terms of what kind of innovations are carried out by what type of size firms. Therefore the Schumpeterian Hypothesis cannot be completely confirmed or falsified based on the data[10] analysed in EII. However, its suggestion on the correlation between firm size and innovation seem to have some currency to it.

With the theory of the firm and the role of the R&D system properly assessed and described we can now take the analysis of the making and facilitation of innovations to a higher level of analysis. Thus, we turn to the national level, analysing how governments and institutions can help foster innovations and diffuse them throughout the production systems and the economy.

[10] The data on which the hypothesis is tested in EII is retrived form OECD in 1969. As such the data are somewhat outdated.

The theory of the firm will constitute the underlying structure of our understanding of the importance of policy on the national level. As a country's economy essentially is made up by its firms and industries, understanding their rationale is essential to comprehend the role of a national system of innovation, and a country's competitive preconditions in international trade. It is therefore with the understanding of the working mechanisms of innovation and the firm we turn to the assessment of the national system of innovation.

2.4 The National System of Innovation and 'Catching Up' in the World Economy

Motivated by the idea of a systematisation and pattern of R&D activities, Freeman presented the idea of a *national system of innovation*. Based on the empirical evidence in EII (Freeman 1974), supporting the notion of systems of innovation (cf. the R&D system), he set out to identify a more general framework at the national level. Later in the paper "Technical infrastructure and international competitiveness", henceforth TIIC, he introduces the concept of 'national systems' (Freeman 1982/2004; Lundvall 2004).[11] However, the full term, namely *national system of innovation*, would not be formalised and consequently referred to as national system of innovation until 1987 in Freeman's seminal book on the Japanese national innovation system (Freeman 1987), "Technology Policy and Economic Performance; Lessons from Japan". In this book he portrays the functioning of such a system and its relevance in 'catching up' in world economic development. This can be interpreted as bringing the analysis of the impacts and effects of innovation on the society and economy from the firm- and industry level to the national level. It is therefore crucial to acknowledge the role of firms within the framework of national systems of innovations and how these levels of analysis interact.

2.4.1 The National System of Innovation

Before we proceed with the analysis of the role of national innovation systems, we will take a quick look at the development of this concept. Both Lundvall and Freeman have been credited for terming and developing this concept. We shall see that Freeman's idea of such a system appears already in his first book EII (1974). The R&D system presented in section *2.3.1* in

[11] Note that even though this paper is referred to as 1982/2004, it was written in 1982, but not published before 2004. This will be helpful to keep in mind for the continuation. For further information see the list of selected works with comments in the Appendix at the back.

many ways is an early conception of a national system of innovation. This point relates to the first feature proposed in chapter **1.2**, i.e. **F1**. Though the term is not consequently applied in EII, the connections between what Freeman calls an innovation system and a national system of innovations is evident. The notion of this innovation system is deduced from the military industrial complex (similar to that proposed by Galbraith (1967)), or military innovation system, which Freeman regarded as the most important in professionalising and bureaucratisation of R&D activity in the 1950s and 1960s (Freeman 1974:288-296). From this military innovation system, Freeman expected a shift towards a system of innovation less characterised by military efforts, and more governed by demand superiority and social objectives. The objective of such a 'social' innovation system is "more complex than that facing purely technical innovators" (Freeman 1974:301), as in contrast to the military innovation system. This complexity lies in bringing back 'consumer sovereignty', and for national policies to stimulate, monitor, and regulate innovations to this end, as "most consumers have benefited from the rise in living standards made possible by the productivity advances due to technical innovation in capital goods, materials and communication systems" (Freeman 1974:297). This, in addition with the observed changing pattern of the direction of research resources (expenditures) and science and technology policy in the US in the 1950s, led Freeman to expect a change also in priorities and values:

> ...military, nuclear and space objectives were rated very low and a much higher priority accorded to 'welfare' objectives – research on the environment, medical research and education. Clearly energy research would now have a very high priority (Freeman 1974:295-296).

This shift in priorities and values underpinned the conception of the social innovation system which main task was to relate consumer sovereignty to innovation and determine the ability of "the political systems and the economy to assess the needs and desires of the population" (Freeman 1974:296). Further, the importance of policy is pointed out: "What science and technology can achieve *is* partly a question of the social priorities and goals set for research" (Freeman 1974:292). As such innovation and research policies are a crucial measure for governments in securing a desirable development, and the priorities and goals set for research is partly communicated through the national system of innovation.

The term national system of innovation was obviously not yet fully crystallised and Freeman operated with several terms similar to this concept in EII, e.g. monopolist or socialist system of innovation and world research innovation system in addition to those mentioned above

(Godin 2010). Generally Freeman was speaking of highly policy oriented and normative 'aspects of public policy for innovation' (which also is the title of the 9th chapter of this book). It was not before TPEP, the book on Japans national innovation system, in 1987 he used the term consequently, and with an explicit intension.

As noted, in TPEP Freeman introduces a more complete and general system of innovative activity than in his earlier writings (Freeman 1987). Here he combines his experiences on the systemic nature of innovation found in his earlier research, cf. (1965, 1968, 1974; 1982; 1982/2004), and the conceptualisation of changes in *technological systems* and *techno-economic paradigms*. The latter term Freeman adopted from Perez (1983) and have used it explicitly since. We shall however get introduced to this concept in section *2.5.2 Techno-Economic Paradigms*. Much of Freeman's explanation of Japan's success as an economic actor in the post war era (1950s-1970s) is placed upon its superior ability to adapt to changes in such paradigms, an ability reflecting the quality of Japan's 'national system of innovation'.

To grasp the concept of a national system of innovation the understanding of the systemic nature of the innovation process is crucial. As we have learned, in Freeman's approach firms do not innovate entirely on their own. The interaction and collaboration between firms and non-firms, such as governmental, educational and financial institutions, policy makers and other social institutions etc, is shaped by the social conventions, norms and laws of a society. These conventions, norms and laws can make up obstacles and possibilities for innovation (cf. the institutional selection environments). Thus, these organisations and institutions are part of the system facilitating the creation and commercialisation of knowledge (R&D), i.e. innovations. Innovations, therefore, emerge in such systems. These systemic linkages are results of the interaction between actors in the selection environments and the institutional structures they constitute. Educational- and research institutions lay the foundations for the creation of new knowledge and (re)-training of the labour force, the financial (and governmental) institutions provide the capital needed to carry out innovation projects, and policy makers facilitate these linkages through regulation of law and public intervention, as in the case of Japan in the 1950s and 1960s (Freeman 1987:32, 39-49).

There exists, however, no canonical definition of the concept of national systems of innovation, and it has not been defined to mean only one thing or to consist of specific things. The term has, as noted, been credited both Freeman and Lundvall. It is however difficult to

decide which of the two authors who was the first to apply and define the term. Their conception of what such a system should be is also rather different. Lundvall's (1992) definition is arguably more instrumental than Freeman's. The national system of innovation is in Freeman's approach first and foremost a conceptual framework, in which one more easily can identify certain institutional and organisational innovations and changes which facilitate the making and diffusion of innovations. As such it is not a clearly demarcated system consisting of certain institutions and organisation. Rather it should be considered as the institutional, organisational, and social and political changes which are deliberately implemented through policies, which facilitate the diffusion and absorption of innovations in the national economy. The national system of innovation is described by Freeman in the following way:

> The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies may be described as the national system of innovation. Freeman (1987:1).

As such the identification of relevant constituent parts is contingent upon identifying the activities and actions of certain institutions, rather than their formal status. For instance, one would suspect the ministry of trade or finance to engage in activities supporting the processes of importing, modifying and diffusing of new technologies, but it is not always so. Thereby, the concept of a national system of innovation in Freeman's approach also opens more up for inclusion of the role of public policy, a matter we know Freeman is deeply concerned with (cf. chapter **2.2**). Further this understanding of national systems of innovation does not conceive the system as a closed and entire system, but rather as interacting with and partly constituting the different subsystems of society, namely technology, science, politics, economy, and culture (cf. **1.1**).

Lundvall's approach is on the other hand more concerned with the national perspective, or rather the formal borders of an innovation system. Lundvall defines national systems of innovation as such:

> A system of innovation is constituted by the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and a national system encompasses elements and relationships, either located within or rooted inside the borders of a nation state. (Lundvall, 1992:2)

This conception of the national innovation system is much more demarcated and implies that these systems are more all-encompassing regarding the factors determining a nation's ability to implement, diffuse, and create new innovations. As such the system itself is a wide conceptual framework of analysis encompassing all important factors for innovation within the territorial boundaries of a nation state.

A certain branch of the institutions, public or private, from Freeman's description of the national system of innovation above, is R&D institutions and their interaction with other institutions and organisations. Priorities in public and, to a lesser extent, private R&D institutions are very much influenced and even dictated by R&D policies. There exists, however, several motives for society to engage in R&D activities, thus initiating certain R&D policies (Freeman 1992 - Chapter 2). Such policies are believed to have certain effects on the ability to innovate, although there is no direct causal relationship between R&D efforts and economic growth. Therefore the introduction of R&D policies rest upon more practical arguments, such as how to measure innovation efforts. Should a nation face a threat in terms of foreign military force, it would, beyond all doubt, benefit from doing military research. In much the same way, a nation could initiate R&D policies to secure its prestige, thus the policy is motivated by a political agenda. Further, reasons concerning economic growth and development, and subsequently welfare reasons (though not always linked to economic incentives and could even at some times be pursued at the cost of economic growth) could initiate certain R&D policies. Last, and perhaps also least, an R&D policy initiative can be motivated by the pursuit of science for its own sake. Alas, such R&D policies are not sufficient to guarantee success in innovation. They merely broaden a nation's knowledge base, and can be of help in imitating imported technologies, not unlike a firm adopting a defensive innovation strategy.

An important point to understand, however, is that R&D policies are implemented in the innovation system, and are not the sole constitutor of such a system. As should be clear by now, these national systems of innovation consists of a wide range of institution (both formal and informal) and organisations. R&D policy is merely one of several tools for governments to use in order to enhance the functioning of the innovation system. However, as it is quantifiable and therefore directly comparable between countries, either as rates or in absolute

terms (Gross Expenditure on Research and Development – GERD[12] is a popular measure of this kind), R&D policy measures justify themselves on practical grounds.

Main features of a well functioning national system of innovation are its abilities to create and maintain healthy relations between the firms and industries and institutions concerning their ability to innovate and imitate, thus providing the necessary conditions for economic growth and trade performance. And as Freeman states (brackets added);

> The closer the interaction between science and technology, the more important it becomes for industrial R&D laboratories to find ways to gain selective early access to the results of fundamental research, especially in universities. Thus the national institutional environment could be an important stimulus to the evolutionary process (of economic growth) or, in other institutional situations, could retard it. (1992:128)

By way of this citation the role of the innovation system becomes even clearer. It also illuminates the role of fundamental research, assigning R&D policy in terms of publicly financed fundamental research an important role as a source of knowledge to develop new technologies. But however strong or weak the correlation between R&D inputs, or outputs, and economic growth (due to innovation) much of the successful use of research and inventions is based upon a nation's efficiency in application. Or as Freeman formulates it; "[just] as firms vary in their efficiency of their innovation management, so do nation-states vary in the efficiency of their *national systems of innovation"* (1987:18). The implications of the innovation system are not to be mistaken. The main function of the national innovation system is to facilitate technical change and innovations, and to diffuse new technologies within the nation's economic and industrial system, ultimately enhancing its competitiveness. Freeman assigns this aspect of a nation's ability to innovate heavy importance. Of course this aspect has wider effects than just facilitating innovation at the national level. We therefore turn to the national innovation system's impact on international trade performance and competitiveness.

[12] The European Union set a goal for its member countries of 3% GERD in Barcelona in 2002. This goal has been controversial as it does not account for individual differences and preconditions between countries for meeting this goal. Certainly, the more developed Western European economies have other preconditions for reaching this goal them the newer Eastern European economies.

2.4.2 'Catching up' and the Role of the National System of Innovation in Trade Performance

The idea of active and protective governmental policies, and even a national system, in international trade is by no means new, although it may be, at least for some, quite unconventional. Friedrich List was one of the protagonists for national systems in the political economy, and especially his idea of 'mental (intellectual) capital' and the critique of classical trade theories have greatly influenced Freeman's formulation of a national system of innovations. List's (1841/2007) assault on 'laissez faire' and comparative advantages in free trade, as well as the classical economics school's conception of the political economy as a cosmopolitan, rather than a national phenomenon, and his plea for national competitive strategies has in many ways found its revival in Freeman's conceptualisation of the subject. This actually becomes quite clear in TIIC (Freeman 1982/2004), where he explicitly states his intellectual debt to List. And in TPEP Freeman (1987:99) even claims that List's conception of a national system in political economy, in essence is a national system of innovation.

The matter at hand requires the introduction of the working mechanisms of 'catching up' before we can unveil the role of national innovations systems in this process. The idea of 'catching up' is based upon the understanding of the world economy as existing of nations and industries with differences in technological level (Freeman 1987:14-19). Thereby we can term some countries technological leaders and some technological followers according to their technological level. Also in these terms lies the notion of a technological leader to be the main driver of technical change, thus also the primary source of such. This approach clearly differs from that in neo-classical economics, where technology is assumed to be evenly distributed and at the same level for all actors (nations), except the contribution of Romer (1986) who introduces a model of long run growth with endogenous technology and increasing returns to scale on inputs of human capital (knowledge). The main rationale, however, in neo-classical theories of trade is that through exploitation of comparative advantages in production, specialisation according to these advantages and to relative prices all participants benefit from trade, as in e.g. the Heckscher-Ohlin model. It offers no trustworthy explanation of the implication of technical change and differences in technological level. Nevertheless, neo-classical theory predicts a convergence in growth rates between countries participating in trade as they exploit their comparative advantages.

The idea of technology being evenly distributed both in time and geographical space should be considered as no less than a naive fictional abstraction from reality. As we have learned, technological change and innovation occur in an inherently discontinuous manner, both in time and place. Further, to assume as neo-classical economics do that new technology is like 'manna from heaven', i.e. its creation requires no inputs and is implemented by no effort, contributes even more to strengthen Freeman's critique of the orthodox approach to the old problem of 'why growth rates differ'. The acknowledgment of differences in both the level of and capacity to create new technology is to Freeman (1987:14-19) crucial in order to understand why growth rates differ between countries. As, following Freeman's rationale, technology offers *absolute* rather than comparative advantages in trade, growth rates will converge when technology levels converge. Further implications of this property are the invalidation of traditional competitive enhancing policies in trade. As being technologically advanced gives absolute advantages in trade, currency policies are being rendered obsolete, as possible comparative advantages in relative prices become irrelevant[13]. With this in mind we return to implications of being a technology leader or follower.

A wide range of empirical research has found a correlation between a country or industry's share of world market trade and its R&D intensity, patents and other measures of technology level (Freeman 1963, 1965, 1968; Gruber et al. 1967). Thus being a technology leader implies being a leader in trade in terms of relatively high shares of total traded volume. Hence, technological backwards countries or industries will have a relatively small share in trade. This point also illustrates the implications of the so-called 'technology gap'. This 'gap' illustrates the difference in technology level between leaders and followers. It is assumed that in order for growth rates to converge, this 'gap' needs to be closed, or in other words, technology and innovation need to diffuse throughout the economic system equalising the technology level between countries. And as we know, Freeman puts great emphasis on innovation as a driving force of economic growth and development. Thus closing this 'gap' implies economic growth due to innovation. There exist some different approaches to close this 'gap' and a parallel to the innovation strategies for firms may be drawn. The decision on what policies to implement rests upon the preconditions and ambitions of a country.

[13] As in the case of Sweden in the years after WWII. The Swedish economy was almost alone in Europe in possessing real capital for production, due to its neutral position during the war, and as most countries in Europe were devasteted after the massive bombings. By this advantage, and repeatedly devalutions of Swedish currency, making Swedish products relatively cheaper to produce, Sweden grew substantially wealthy, becoming one of the richest countries in the world in the post-war era, cf. Dahmén (1991).

However, the closing of this ‘technology gap’ is by no means a straightforward business; each country faces different challenges and possess different resources, thus having different conditions to do so. Here, the role of a national system of innovation comes in to play. The potential of a country to ‘catch up’ if it is not a technology leader is greatly determined by the ability of its national system of innovation to make use of imported and imitated leader technology and diffuse it throughout its economic system.

As a country is ‘catching up’, and as the technology and productivity gap is closed, convergence in growth rates are diminishing. This is due to the relatively small efforts needed to import and imitate technologies from leading countries, and as the gap closes this advantage is eliminated. This was the case for Japan in the 1950s and 1960s, when it converged to the leading countries through imitation and import of technology. The big challenge lies in upholding the rate of growth in technological activities, which in turn is dependent on *basic science*. As a country becomes a leader, a much greater R&D effort is required to maintain the technological growth, and to stay ahead, as it requires novel technologies, when one no longer can imitate (Freeman 1987:26-28). Therefore investment in basic science is essential to stay in the game. But, as we have learned not only basic science is required in producing and diffusing innovations. However, efforts in such are more easily measurable than e.g. institutional factors which also contribute to the constitution of an innovation system.

One major limitation of purely quantitative analysis as that expressed above, is that it fails to include institutional factors, such as new ways of organising production, investment and marketing, and novel ways of combining inventions with entrepreneurs, thus ‘matching’ inventions with market demand (Freeman 1987 - Chapter 2). Also changes in the education and organisation of science and R&D are such institutional innovations important to the success of a technology leader. Britain’s and Germany’s opening of the ‘technology gaps’, or forging ahead, during the industrial revolution and in the late 1800s respectively, were coloured by these institutional changes. Without them, inventions would have been left unexploited.

As both institutional arrangements, engagement in basic science, and fundamental R&D are all parts of a national system of innovations, its role in ‘catching up’ is beginning to

crystallise. How advanced a nation's innovation system is, determines its potential for 'catching up'. And as Freeman points out on the role of basic science in potential for economic growth;

> In considering the significance of these results for economic performance it should be remembered that what is at issue is the ability of a national science and technology system to make use of the results of world science to advance national technology. It is certainly the case that it is impossible to understand and assimilate new advances in many branches of science without an active participation in the world scientific community. Moreover, it is also the case that the interdependence of science and technology is increasing and some of the most important new generic technologies are intimately related to basic science. (1987:30)

It will of course not always be so that any country not being a leader can invest in basic science and expect to 'catch up' and be a leader; all countries cannot be leaders. For countries struggling to keep up, the vast expansion of leading and 'catching up' countries leave them falling behind. The way out of such a quagmire is not easily paved out. There are factors outside the national innovation system which affects a countries potential. Political (institutional environment) and natural conditions (natural environment) are of crucial importance. Political or governmental instability can contribute to a bad financial climate, scaring away investors and creating distrust to policy makers (see e.g. (Fagerberg and Srholec 2008). Further, the access to resources and inputs in production out of reach of an innovation system to improve or alter will play a decisive role in which countries are allowed a prosperous economic future and which are not. The role of selection environments on the national level is obvious in this context.

2.5 Systems of Change

As promised in the section on a taxonomy of innovations, we return to the concept of techno-economic paradigms. These are believed to be the main driving force of so-called 'long waves' in world economic development. There exists a variety of approaches to this statistical phenomenon (cf. (Kondratieff and Stolper 1935; Mensch 1979; J. A. Schumpeter 1939; van Duijn 1977)). All these approaches, expect Kondratieff, are motivated by the role of technical change and innovation in long run economic development, but their explanations and rationale differs. However, we are to concentrate on the approach to this phenomenon along the lines of Christopher Freeman, and, when fruitful, contrast it to some alternative approaches.

The main idea of a techno-economic paradigm is sketched out in the taxonomy of innovations. It is a so profound, far-reaching and all-encompassing change in technological system that it influences and command the direction of economic and technological development. In order to understand the working mechanisms of such paradigms we need first to go deeper into the meaning of technological systems. As proposed earlier (cf. the taxonomy in section *2.1.1*), a combination of such technology systems can constitute a new techno-economic paradigm. Therefore, in order to understand the working mechanisms of techno-economic paradigms, we need to understand technology systems.

2.5.1 Technology Systems

As presented in the taxonomy, technological systems contain innovations combined in a variety of ways, such as to have widespread effects on productivity- and output growth in different sectors and industries. As such, new technology systems can be conceived as constellations of innovations which are technically and economically interrelated and are capable of terminating old industries and creating new ones.

The working mechanisms of technology systems and techno-economic paradigms are much alike, and the crucial difference lies in the potential of diffusion and transcendence of the systems beyond the industries and countries of origin and the social and institutional changes required. As we know, the term techno-economic paradigm was used by Freeman first after his collaboration with Carlota Perez in the early 1980s, but after the publication of UTI in 1982. It was not before TPEP that Freeman used this term explicitly, after Perez's (1983) paper where she developed this term. Therefore we analyse these technology systems before assessing the theories of techno-economic paradigms.

Freeman developed the technology systems based on earlier conceptions by Nelson and Winter (1977) and Dosi (1982). As such technology system can be seen as a parallel to 'technological paradigms' as proposed by Dosi with similar evolutionary characteristics as Kuhn's (1970) scientific paradigms, i.e. they are governed by revolutionary changes in technology. Further, these technology systems are believed to follow a 'general natural trajectory' as described by Nelson and Winter (1977). They point out that very general trajectories of technologies are associated with the exploitation of economies of scale, an idea Freeman puts great emphasis on (Freeman et al. 1982:73-75). In this book Freeman develops

the idea of technological systems based on these 'natural trajectories', which besides is his first real attempt to create a framework of technological systems at a macro level. These 'natural trajectories' consists of three main features. As basic innovation and a small cluster of related (basic) innovations offer radical changes in production and profit possibilities, firms in position to do so make use of 'natural trajectories' of technologies to exploit economies of scale (cf. *2.3.2 Firm Innovation Strategies*). New technologies generate labour shortages leading to increased demand in labour saving technologies, exploiting the potentiality of the 'general natural trajectory'. These labour saving technologies are often implemented as process innovations. As such one would assume industrial innovation to lead to structural changes, as also is pointed out in the taxonomy. These structural changes are also closely connected to the uneven distribution of technology and differences in technology levels between industries, as well as the lack of equilibrium in the market:

> In Schumpeter's framework it is disequilibrium, dynamic competition (in the sense of 'imperfect' competition) among entrepreneurs, primarily in terms of industrial innovation, which forms the basis of economic development. ... In such a framework economic development will be viewed primarily as a process of reallocation of resources *between industries*. That process leads automatically to *structural* changes and disequilibria, if only of the uneven rate of technical change between industries. (Freeman et al. 1982:31-32)

There also is another aspect of the relation between labour and technical change. As new technology is applied in production, one is likely to observe a massive displacement of labour, and also other inputs in production. We shall, however deal with the case of technical unemployment in a later section (*2.5.3 System Maturation, Unemployment, and Productivity Growth*).

However, the diffusion process and its implications are of crucial importance. It distinguishes the effects from when a radical, or basic, innovation occurs on its own, as the mere occurrence imply no major economic effects. Only with the diffusion of a new technology, creating new markets, through new products and processes, additional demand is a fact, and the 'spin-off' and 'spill-over' effects is manifested in surrounding industries one will see the social and economic effects of a new technology, or more precise, a new basic, or radical, innovation (Freeman et al. 1982:68-73). Thus, inter-related clusters of innovations and their diffusion through the economic and social systems of several branches and regions is the new technology system. These changes, and the structural changes they induce, are believed to undermine existing industries as well as giving rise to entirely new industries and sectors. In

the book where these systems are defined and explored, UTI gives a credible account of the post-WWII structural changes in the world, based on an extensive use of tables and figures deduced from statistical evidence of growth rates of industries, employment/output rates of nations, and industrial concentration in world leading countries (UK and USA). We shall however not go into further detail on these statistical accounts (as explained in the introduction). Suffice to say, they underpin the theoretical suggestion on technology systems presented above.

One point of major importance in relation to the diffusion process is that innovations change during this crucial diffusion process. This was not, however, explicitly stated in early models of diffusion in the 1950s and 1960s, and they met heavy criticism by e.g. Metcalfe (1981) and Rosenberg (1976, 1982; Kline and Rosenberg 1985). And as Freeman also points out innovations are constantly the subject to incremental improvements and alterations. This is, according to Freeman (1994:480-481), mainly due to the learning process of innovations and the competitive pressures engendered in so-called 'bandwagon effects'. These incremental innovations that take place during diffusion are evident in the case of e.g. automobiles. Even Schumpeter (although often criticised not to) recognises this point in the case of automobiles:

> ...the motor car would never have acquired its present importance and become so potent a reformer of life if it had remained what it was thirty years ago and if it had failed to shape the environmental conditions – roads among them – for its own further development. (J. A. Schumpeter 1939:167) cited in (Freeman 1994:481)

These changes offer obvious advantages in establishing a new technological system, and even a new techno-economic paradigm. Thus understanding the diffusion process is of crucial importance to understand the establishment of technological systems and techno-economic paradigms. Moreover, in this changing of environmental conditions, as Schumpeter called them, lies also the implication of 'creative destruction', as these new conditions require destruction of the old structures of society. This will however be dealt with in detail in the next section.

We now turn to the working dynamics of such technological systems. The importance of diffusion of the new radical technology is pointed out. However, as such a crucial component in constituting a technology system, it deserves more attention. In a Schumpeterian model the profits realised by innovators are the decisive impulse to surges of growth, acting as a signal

to the swarms of imitators, forming booming clusters. However, only a few innovators and imitators realise these super-profits, because not all firms and actors are capable of exploiting the new innovation, due to lack of absorptive capacity (*2.3.2 Firm Innovation Strategies*). As the technology matures and diffuses throughout the system, it becomes more available to more firms, and profits decline. This effect is considered as a 'competing away of profits', and will be true for practically all types of innovation in one or another stage of its life cycle. Within this understanding we can assume that profit motives lead to this crucial diffusion of new radical innovations, constituting a new technological system. As the profits are competed away, new technologies and innovations are required to obtain new super profits. This dynamism is placed at the core of explaining capitalist competition in Freeman's conception, and also one of the main incentives of producing innovations. However, Freeman does not express an over-excitement for the free market solution, and we should expect capitalist competition to not be the only incentive for innovation in his approach. As pointed out earlier, Freeman assigns the public and governmental interests an important role in encouraging innovative behaviour. Such encouragement is imparted through the *national system of innovation*. And such systems are crucial not only to encourage innovations, but also in the process of diffusion. A well-functioning innovation system facilitate diffusion through policies and institutional arrangements leading firms to more easily adapt to change, and sometimes even making innovation and imitation a more profitable activity (cf. **F2**). As we know, undertaking innovation can be a risky project, and such risks can be mitigated by governmental measures such as direct and indirect subsidies (tax exemptions etc.). Thus, along the lines of Freeman, there is a systemic interaction between the national system of innovation and the technology system, where they each substantiate each other.

The role of demand in innovation has been stressed in earlier sections. It also comes into play here. As technological systems are in essence initiated by new radical technologies, the role of demand must be of importance. However, whether it is created or existing demand is not as important, as whether it is market or government demand. As governmental procurement can, directly or indirectly, dictate the demand structure for new products or processes, it must be considered a major policy measure. Thus, it becomes a part of the national systems of innovation, constructed to facilitate innovations and their diffusion. The systemic interaction is evident also here.

However, these technology systems should be considered an alternative approach to the theory of the clustering of innovations asserted by Schumpeter (1939), and also the theories of Luigi Pasinetti (1981) and Gerhard Mensch (1979), the two latter which we shall be better acquainted in sections *2.6.1* and *2.6.2*. This is however given that these technology systems are pervasive enough and transcend the borders of the industries and country of origin. We analyse the effects of such pervasive systems, through analysing the working mechanisms of techno-economic paradigms.

2.5.2 Techno-Economic Paradigms

When such changes as those described above are not limited to affecting only certain industries and sectors, but diffuse throughout the entire economic system, across industries and across countries, a techno-economic paradigm is constituted. Further, these techno-economic paradigms can consist of a constellation of technology systems (as proposed in the taxonomy in section *2.1.1*). The term techno-economic paradigm is originally developed by Carlota Perez in her seminal paper "Structural change and assimilation of new technologies in the economic and social systems" (1983), and later adopted by Freeman. The term is chosen as the widespread effects of technical change affect not only the technology system, but also the principles in which the economic system is organised (Freeman and Perez 1988:47). Along these lines one would also presume some repercussions in society or adjustment in the socio-institutional framework (this point relates to the feature proposed in **F2**). Much like the national system of innovation works as a diffusion mechanism for technical change and innovation, these socio-institutional frameworks work as facilitators of the diffusion of a new techno-economic paradigm. Thus changes in such techno-economic paradigms require some institutional and social change and adaption in addition and in harmony with the structural and physical changes described above. As Freeman (1987:116) points out:

> the institutional changes which are needed include changes in the education and training system, the industrial relation system, managerial and corporate structures, the prevailing management styles, the capital markets and financial system, the pattern of public, private and hybrid investments, the welfare services and income distribution, the legal and political framework at both regional and national level and the international framework within which trade and investment flow and technologies diffuse on a world wide scale. It is easier to identify the problems than to provide specific solutions, which must be a matter of imaginative social innovations and experiment.

The massive social and institutional changes required for a change in techno-economic paradigm are beyond all doubt (this can be seen in relation to **F2**). This fact along with the sheer scale of techno-economic paradigms, are what first and foremost distinguishes it from a technological system. Further it requires an overwhelmingly far-reaching and profound diffusion and adaption process. Such changes are often associated with painful transitions and rearrangements in both the economic and social systems, as new technologies, management styles and institutions are required to exploit the potential of the emerging paradigm. These changes are painful in the sense that they brutally tear down existing structures, outdated and unfitting for the new managerial and engineering common sense leading to massive scrapping of real capital (production capital) and displacement of labour, as well as re-structuring in the financial system, as new investment opportunities emerge. This obviously involves the disappearance of some industries and sectors, but in their wake new industries and sectors emerge, attracting labour and investments, creating new opportunities for economic growth. Further it affects the nature of economic growth. As opposed to the neo-classical conception of the growth pattern as a smooth overall natural rate of growth, these destructive mechanisms induce another pattern of growth. As Freeman point out:

> ...it is obvious that economic growth is far from a smooth, homogenous process. Underlying overall macro-economic growth one finds industrial sectors that are virtually disappearing and totally new sectors that are just emerging. (Freeman et al. 1982:127)

These changes are however painstakingly slow, as they require training and re-training of labour, institutional adjustment to fit the new financial structure, and the scrapping of old real capital and introduction of new real capital embodying the technical changes, and all fitting the new common sense, or rather paradigm. These mechanism bear clear similarities to the Schumpeterian concept of ‘creative destruction’. It is of crucial importance to acknowledge the role of national systems of innovation, R&D systems and institutions required to initiate and facilitate the diffusion of innovations with potential to induce such widespread changes and establish a new techno-economic paradigm. It is however important to point out that these dynamic mechanisms of creative destruction are not a zero-sum game (see e.g. Watson (2008) for an introduction to such games), i.e. the overall total of capital, production and consumption are not constant during these phases of displacement and substitution. Rather, the overall total of production and consumption possibilities is optimally increased.

In this context it could be useful to present some stylised facts on the evolutionary nature of techno-economic paradigms. This is just as much as to detect some recurrent phenomena in the evolution of such systems and their transition, as it is a detailed exposition on the nature of such paradigms. As Freeman states both on the evolutionary characteristics of techno-economic paradigms and on the history of economic development: "the fundamentals still apply, as time goes by, even though each period has its own unique characteristics" (Freeman and Louçã 2001:123). However, this leads us to an evolutionary characteristic of such paradigms consisting of basically six phases (Freeman and Louçã 2001:146): *i)* The seeds of a new techno-economic paradigm are sowed in an early phase of laboratory-invention, with early prototypes, patents, small-scale demonstrations and early applications of new technologies. *ii)* Given a potential of success in these technologies, decisive demonstrations of technical and commercial feasibility are carried out, often with widespread potential applications. *iii)* Success in this latter phase lead to an explosive take-off and growth during a turbulent time of structural crisis in the economy and the political crisis of coordination, adapting to the new regime of regulation. *iv)* As a new regime emerges, the high growth continues and the system, or regime of regulation, is accepted as the dominant technological regime and best common sense in the leading countries in the world economy, and is applied in a still wider range of industries and services. *v)* The system matures as slow-down in growth and erosion of profits becomes dominant, and the system is challenged by newer technologies. *vi)* This in turn leads to new *crisis of structural adjustment*. In this maturing phase one can expect some renaissance effects possible by unique combinations offering a fruitful co-existence between old and new technologies. However, the ghost of inhalation hovers restlessly over the old regime, resulting in slow disappearance of old technology and industries.

How are we going to understand the evolution of techno-economic paradigms? However stylised the above presentation may be it highlights the main point in Freeman's understanding of such evolution. The essential point to grasp is the general lines along which these techno-economic paradigms evolve. And from the presentation of Freeman's conception of the process we understand that each new paradigm initially emerges within the existing one. This implies a socio-economic system which tolerates and even encourages variety and experiment. However, the new technology becomes established as a dominant technological regime only after a long period of gestation and competition with the previously dominant technologies. It has to prove its potential and actual profitability first in one or a few

industries, and its full success occurs only after a crisis of structural adjustment entailing deep social and institutional changes and the replacement of the leading motive branches of the economy. The reasons for the mismatch arise from the different rates of change in various parts of the system as well as from inertia in the built environment and the social institutions.

2.5.3 System Maturation, Unemployment, and Productivity Growth

The maturing and declining phase constituting the crisis of structural adjustment is of particular interest in understanding the role of technology systems and paradigms in the long wave approach. We therefore turn to some of the main working mechanisms of the maturation phase and some structural changes inherent in it.

One of the consequences of the cyclical nature of economic development, and the concomitant structural changes, is, as pointed out earlier, unemployment. This is a topic Freeman puts great emphasis on. The social and economic consequences of unemployment are important both in respect to social and economic welfare and of course also to economic performance. There are also other structural changes in relation to maturation of technology systems and techno-economic paradigms which will be pointed to here, concerning productivity growth and pricing behaviour.

By means of the rationale of structural changes portrayed in the section on *Technological Systems* (*2.5.1*) it makes sense to speak of a technical unemployment in Freeman's framework, which in essence must be involuntary. Thus the conception of the non-existence of involuntary unemployment and a non-inflationary natural rate of unemployment (NAIRU) makes no sense in this framework. Both these conceptions are to be found in orthodox economics, which Freeman takes a clear stance against (cf. (Freeman et al. 1982 - Chapter 1; Freeman and Soete 1994 - Chapter 2)). The labour displacements set forth in Freeman's approach can be interpreted as a result of structural change, a necessary consequence of technical change and the implementation of technical inventions and organisational innovations. Thus social change also is a necessary consequence of technical change and innovation. The dynamics of this involuntary technical unemployment is understood within the long wave development framework. The differences in Freeman's approach and the neo-classical approach are best expressed in his own words:

> One of the main reasons why classical and neo-classical macro-economic growth theory (even when formally introducing technical progress) is of so little relevance to our long wave discussion, lies in the implicit assumption that technical progress (just like population growth) can be expressed in terms of an *overall* rate. This implies that not only is the rate of technical progress identical in all sectors of the economy, but also that demand growth is uniform across sectors. In such a world, full employment is actually difficult to 'avoid' and even the attainment of a perfect 'natural' dynamic equilibrium growth path, or even a so-called 'steady state', is pretty straightforward. If this were true, orthodox economists would indeed be quite justified on spending most of their time on more important 'short run' static problems (Freeman et al. 1982:131-134).

It becomes quite clear from the rather lengthy citation above that short run static analyses are insufficient to give a plausible explanation of economic growth and development. Freeman synthesises the working mechanisms of the business cycle and its inherent structural changes including technical unemployment as such:

> It is in relation to these [maturing] industries, where the possibility of expanding demand is limited, that rapid technical progress will lead most directly to 'technical unemployment'. In many ways, one could identify 'depressions' as those periods in which the industrial structure is fundamentally unbalanced by an increasing number of industrial sectors entering their declining phase, and a decreasing number of expanding industries. The depression will last until sufficient capital is scrapped and redirected in the expanding sectors of the economy. (Freeman et al. 1982:134)

In Salter's (1960) model employment is contingent on two factors; the price elasticity of demand (output) and the productivity elasticity of prices. As productivity increases, output grows, in turn leading to decreasing relative prices on goods, which benefits the consumers, i.e. as relative prices fall demand increases. In turn, with sufficiently high price and productivity elasticises, productivity growth should induce growth in, or at least maintain, the level of employment. This does not, however, hold for the empirical evidence from the manufacturing industries in the post-war economy. Actually the contrary is true for the manufacturing sectors in the UK from 1973-79, where there is an inverse, or negative correlated, relation between productivity growth and employment (Freeman et al. 1982:134-141).

The process of rapid technical progress in the early phase of a booming long wave creates new industries, and lead to rapid growth in branches of large firms which promote that new technology (Freeman et al. 1982:134-141). In the early phases of a booming wave the structure of new industries are highly unstable, due to innovators being forced to take

substantial risks, with very little scope of preventing imitation, thus failing to innovate. In the maturing phase of the industry entering becomes even harder, and even more in-desirable, with the 'competing away' of profits. Also the pricing strategies of an industry shifts as it becomes more mature. In the early phase, with high risks, one could expect a monopoly pricing behaviour, and all productivity gains would fall in the hands of the capital owner. As technologies diffuse, imitators emerge and the risk of innovating is decreasing, one would expect a more competitive pricing strategy, often with dramatic fall in prices. In the more mature phase, one would expect somewhat of an oligopolistic price setting, where prices are set by the leading firms or by an elaborate price cartel agreement.

As the entry of imitators tend to compete away profits in a semi-mature phase, prices fall and benefit the consumers, i.e. productivity growth benefits shift from the capital owners to the consumers and increases consumer possibilities. However, one would expect yet another shift in productivity growth gains (Freeman et al. 1982:141-148). As the shift of benefits from capital owners to consumers make entry to the industry less attractive, growth is clearly identified, and there will be a shift from the relatively open competitive pricing to a more closed oligopolistic pricing behaviour as firms will use static and dynamic economies of scale to their best advantage. This will in turn benefit the employees as a result of capital owners wanting to please their workers, weakening their loyalty to the unions and 'buy' social peace. As such the workers interests can be the firm's interest. However, foreign competition can offset this balance through absolute cost advantages. The productivity gains from trade in such a scenario will again benefit the consumers through lower prices. The most probable long run outcome of this is however an international oligopolistic pricing behaviour.

2.6 Long Waves in World Economic Development

The idea of economic development manifesting itself in a sigmoid pattern, often referred to as long waves, or Kondratieff waves, has its origin in the statistical discovery made by the Russian economist/statistician Nicolai Kondratieff (1926; 1935) in the early 20th century. His measure of the history of economic growth dating back to the industrial revolution in Britain in the late 1700s, shows a distinct wave-like pattern, with troughs and peaks approximately each 40-60 years.

This exposition of economic development taking form as 'long waves' described by inter alias Kondratieff (1926), Schumpeter (1939) and later Mensch (1979), Pasinetti (1981) and Freeman (1982; 2001) have through the years earned some acknowledgment among historically oriented economists and economic historians. The fact that they all confined to this long wave pattern is not, however, to say they all made use of the same tools or theories to explain it. Kondratieff was strictly econometric in his approach, a method insufficient to describe the qualitative complexities of economic development along the rationale of Freeman's approach. However, Schumpeter, Freeman, Mensch and Pasinetti all seem to agree upon that the main driver behind this sigmoid pattern of economic development is technical change and innovation. Fitted into Freeman's framework the long wave pattern correspond to successive changes in techno-economic paradigms (cf. **F3**). Each new paradigm is constituted by a cluster of radical innovations and diffused throughout the economic and industrial system. With this diffusion comes major opportunities of profits and booming clusters emerge leading the economic system into an upward swing. As the technologies mature and markets saturate, new technologies emerge and compete with the existing regime. During this battle productivity stagnate, profits decline and the economic systems enter a downward swing. This trend is not turned before the new competing technologies and management styles are established as the new common sense, the new techno-economic paradigm. Then again the economic system is thrown into a new upward trend with booming clusters. And so goes the dance, repeatedly, but each period with its own idiosyncratic characteristics. Here the so-called 'bandwagon effect' plays an important role:

> The bandwagon effect is a vivid metaphor and it relates to a rapid diffusion process which occurs when it becomes evident that the basic innovations can generate super-profits and may destroy older products and processes. (Freeman et al. 1982:67)

As such, it is seen to be the most important contributor to the upswing in 'long waves'. It shows how the role of diffusion, as stressed above, is important in creating new techno-economic paradigms, of course along with the general applicability of the new innovations. As this pattern repeats itself, more or less regular phases of contraction and expansion in world economic development appear. These phases are referring to the peaks and troughs in the long wave pattern, and the main driver of these are the diffusion of innovations transcending the firm/industry level, through the national level, and finally imposing its implications on the global level. Implications of innovations not transcending these levels are believed to drive the shorter-run business cycles such as the Kitchkin cycle (replacement of

inventory/smaller production equipment 3-5 years), Juglar cycle (replacement of fixed investment such as larger production equipment 7-11 years), and Kuznets cycle (replacement of infrastructural investment such as buildings 15-25 years). On top of all these cycles we have the Kondratieff cycle, i.e. long wave cycle, with peaks and troughs approximately each 40-60 years, and whose rationale and working mechanisms are explained above.

Similar to Schumpeter's 'gales of creative destruction' is the successive changes in techno-economic paradigms conceived by Freeman, implying crises of adjustment and reconstruction of capital and institutions, ultimately driving the sigmoid pattern of world economic development. It is mainly within this framework the Freeman's ideas unveil their logic and working mechanisms. Here all his different systems and linkages are bound together offering a holistic understanding of economic development. There is however other approaches to the working mechanisms of this long wave pattern. Below is presented some alternative views and Freeman's response to them.

Before we turn to these alternative approaches we will devote some attention to some thoughts on the connection between the process of 'catching up' and the long wave development. The 'catching up' process is basically unrelated to the overall long wave up-and downswings. However, it is of interest, as it depicts the potentiality in technology diffusion between countries. Technology followers, close to the leading countries, in technological terms, will experience high growth rates due to diffusion of new technologies. This growth is expected to be decreasing as the follower-countries close in on technology leaders, whereas the decline in growth of the leading countries one would expect will be a direct result of the overall turning, or downswing, in the prevailing long wave. Such a downswing could represent a welcome pause for the follower-countries, as the leading countries comes to a halt in technical progress, and the followers get time to work their way in the exclusive club of technology leaders, as the technological level evens out in time. One would expect some degree of convergence between certain countries, after a period of divergence in the booming phase. Freeman (1982:182-189) argues that the process from convergence to divergence can be explained by the recovery of a downswing in a Kondratieff wave, based on the clustering of inter-related innovations in the old or some new technological leader. This process, the recovery, will by its clustering of innovations create divergence for some time, and then later as the technology diffuses in the economic system and the technology matures lead to a convergence between technology leaders and followers.

The above exposition can be condensed into a somewhat illustrative table showing seven stylised facts of each of the long waves identified since the industrial revolution in the late 18th century. The below presented table is based on Freeman and Louçã (2001:141). The idea is to present what is believed to have been the most important and significant features of each techno-economic paradigms driving the long wave pattern.

Table 2.6: Seven Stylised Facts of Long Waves

Constellations of technical and organisational innovations	**Examples of highly visible, technically successful, and profitable innovations**	**Carrier branches and other leading branches**	**Core inputs and other key inputs**	**Transport and communication infrastructure**	**Managerial and organisational changes**	**Appr. upswing (booming)/ Downswing (crisis of adjustment)**
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Water-powered mechanisation of industry	Arkwright's Cromford mill (1771) Henry Cort's 'puddling' process (1784)	Cotton spinning Iron products Water wheelers Bleach	Iron Raw cotton Coal	Canals Turnpike roads Sailing ships	Factory systems Entrepreneurs Partnerships	1780-1815/ 1815-1848
2. Steam-powered mechanisation of industry and transport	Liverpool-Manchester Railway (1831) and Brunel's Great Western Atlantic Steam ship (1838)	Railways and equipment Steam engines Machine tools Alkali industries	Iron Coal	Railways Telegraph Steam ships	Joint stock companies Subcontracting to responsible craft workers	1848-1873/ 1873-1895
3. Electrification of industry, transport and houses	Carnegie's Bessemer steel rail plant (1875) Edison's Electric Power Station NY (1882)	Electrical equipment Heavy engineering Heavy chemicals Steel products	Steel Copper Metal alloys	Steel railways Steel ships Telephone	Specialise professional management systems 'Taylorism'	1895-1918/ 1918-1940
4. Motorisation of transport, civil and war economy	Ford's Highland Park assembly line (1913) Burton process for cracking heavy oil (1913)	Automobiles Trucks Tractors, Tanks Diesel engines Aircrafts Refineries	Oil Gas Synthetic materials	Radio Motorways Airports Airlines	Mass production and consumption Fordism Hierarchies	1941-1973/
5. Computerisation of entire economy	IBM 1401 and 360 series (1960) Intel microprocessor (1972)	Computers Software Telecommunication Biotechnology	Chips' (integrated circuits)	Information-highways	Networks; internal, local and global Flexible specialisation	1973-???

2.6.1 Freeman versus Mensch; Do Innovations Overcome Depressions?

The feud between Freeman and Mensch in the 1970s-and 80s was essentially concerned with the difference in the understanding of the innovation process. In Mensch's framework, what he term fundamental innovations tend to cluster in periods of economic recession and stagflation (both inflation and unemployment rates increase simultaneously). Fundamental innovations are the equivalence to what we call radical and basic innovations. The title of the book chosen as the outset for this comparison, "Stalemate in Technology; innovations overcome the depression" (Mensch 1979), highlights the central assumption in Mensch's theory. Following the peak of a so-called long wave, he believes that there is a stalemate in technology, a situation where successful innovation comes to a halt. The argument of this hypothesis is that as the industrial system matures it will not allow radical innovations to diffuse. Rather, incremental innovations will accumulate, constantly seeking to improve the established industrial system. However, as this stalemate fail to produce demand-enhancing radical innovations, the economy will enter into a recession or a period of stagflation. This dictates a breakdown of the existing industrial system, allowing radical innovations to occur and diffuse, creating new grounds for economic growth. The central notion is that radical innovations seem to cluster in time, i.e. in periods of recession. Mensch terms this the 'discontinuity hypothesis' (Mensch 1979), perhaps motivated by the fact that radical innovations occur within this frameworks discontinuously in time.

A crucial point is the time from invention to implementation, i.e. lead time in innovation. What Mensch suggests is that recessions act as an accelerator on the lead time of radical innovations, i.e. lead time of radical innovations is shorter in recessions than in periods of economic growth. This he terms the 'acceleration principle'.

By combining these two phenomena Mensch unveils his explanation of how innovations drive economic development; Periods of recession and stagflation is overcome by the reduction in lead time in innovation, thus clustering radical innovations in time, and the industrial system breaks down, leading to new radical innovations founding a new ground for growth. As the new system matures, radical innovations disappear and the system enters a new period of decline in growth and finally goes into recession. Repetition of these mechanisms leads to a

pattern of economic development similar to the cyclical pattern of economic growth portrayed earlier.

Freeman, however, has a different understanding of what drives this sigmoid pattern of growth. The critique of Mensch's hypotheses is explicitly expressed in Freeman et al. (1982 - Chapter 3). They support Mensch in his crucial distinction between radical (fundamental) and incremental innovations. However, this is nearly all they agree on. First of all, they find the empirical basis for the 'discontinuity hypothesis' too weak. Mensch's data is based on the Jewkes et al (1958) list of fundamental inventions, mainly based on patent statistics. We know already the crucial distinction between invention and innovation, and it is needless to say that this is an obvious weakness in the empirical foundation of Mensch's work. Further is pointed out the less than useful requirement to lead time. If an invention is not implemented within ten years, it is excluded from Mensch's analysis. This obviously reduces the data set, and even turns out to be favourable to his hypothesis. Mensch identifies a clustering of fundamental innovations in the 1930s shortly after "The Great Depression" substantiating his theory of discontinuity. However, if the lead time requirement were extended to twenty or even thirty years various radical innovations, according to Freeman et al. (Freeman et al. 1982:47), appear in the 1920s and even the 1940s, weakening the 'discontinuity hypothesis'.

Also the 'acceleration principle' falls under heavy attack. In the same way as the empirical data set fails as proof of the 'discontinuity hypothesis', it fails in supporting the acceleration principle. Freeman et al (1982:54-55) calculate new estimates for the lead time of the selected innovations and find a pattern quite different to that of Mensch. They argue that the original estimates are constructed on basis of an arithmetic error. Therefore they reject the theory presented by Mensch, and claim no clustering in time of radical innovations or acceleration of lead times in periods of recession. Rather, the exposition above on the working mechanisms of the long wave patterns is upheld. Systems of R&D and public policy inducing innovative activity are placed at the centre for Freeman's explanation. Or in Freeman et al. (1982:80) own words:

> A depression should not be necessary to generate a revival of growth and the task of intelligent economic and social policy is to find the way to stimulate a new flow of desirable combinations of technical innovations and social changes to prevent prolonged depression.

2.6.2 Freeman and Pasinetti; What Drives the Learning Rate in the Economy?

As economic growth can be considered as contingent on demand, an alternative definition of recession can be constituted when productivity growth exceeds the increase in demand, a more or less typical Keynesian demand-deficiency. This is due to increasing effects of saturation in large numbers of existing mature goods and failure to identify new consumer wants. Pasinetti (1981) argues that standard Keynesian demand-stimulating policies will fail in the latter of the causes of recession. Clearly, such policies will help to increase demand in existing sectors, but cannot battle the structural demand changes, i.e. they provide no tools to identify new consumer demands, and in the same consequence are in itself unable to cause a resumption of economic growth. Keynesian policies can therefore only limit the damage of a recession. The identification of new consumer demand, in order to resume growth, can only be done by *speeding up the rate of learning*, according to Pasinetti. Large multi-product firms have an advantage in this process, as it has back-logs of earlier ideas and research and possesses a large amount of R&D staff. This logic also offer support to the Schumpeterian hypothesis. However, Freeman et al. (1982) assigns a different actor the most important role in speeding up the rate of learning (brackets added):

> The most crucial factor affecting this rate [of learning] is, of course, technical progress itself, which through the development of primarily new products and through process innovations will enable effective demand to 'recover' – either by allowing new consumer wants to be satisfied through new or improved products, or by broadening the scope of consumer satisfaction of existing goods to lower income classes. (1982:142)

However, Pasinetti's system treat technical progress as taking place as a continuous process, although differentiated between sectors, while Freeman consider technical progress as a fundamentally discontinuous process (cf. the taxonomy in section *2.1.1*). Furthermore, the question of whether the large multi-product firms are the most inductive or efficient in identifying new consumer wants, thus enabling the system to speed up its rate of learning, depends in the first instance on its technological commitment, which might well be in a large number of relatively mature consumer wants. Thus, the advantage set forth earlier in large multi-product firms, is not obvious. Pasinetti delineates a Mark II sort of model, one which has been shown suits the development in the post-war economy rather good. However, the resurgence of Mark I small firm innovators are also closely linked to the long term cyclical development. As stressed throughout earlier sections, the combination of Mark I and Mark II seems to be a comprehensive approach to understand post-war structural changes and

emergence of a long wave boom. The essential question is therefore which of the two types of firm which engages in new markets. Large multi-product firms may well do so, but some of their profits on new products can be expected to cover deficits in the mature markets, leading investments away from the new technologies and products, leaving the potential unexploited. Therefore small and highly innovative firms plays an important role in getting out of recessions, as they exploit the full potential in new market demand when identified. We know, of course, that this mechanism is a strong engine in resuming growth when in a recessive cycle.

2.7 A World of Systems; Freeman's Theory of 'Reasoned History'

This chapter is mainly concerned with the last book Freeman wrote on the evolution of capitalism. It will present the theoretical framework of 'Reasoned History', consistent of the five subsystems presented in the introduction and how this approach offer a holistic understanding of the history of economic growth in the world economy. The concept of a 'Reasoned History' is deduced from Schumpeter, see e.g. "The Explanation of the Business Cycle" 1927. In this paper Schumpeter calls for a reasoned approach to a theory of the business cycle in order to construct a theory of "...complete explanation of all that happens. This can only be found in a 'Reasoned History' of industrial life." (Schumpeter 1927:298). As such this Theory of 'Reasoned History' can be considered as the complete Social Economics of Freeman in accordance to the definition by Swedberg presented in Part One, providing a complete explanation of the process of capitalist evolution understood as interaction between economic and social elements. Thus a crucial task is to connect this Theory of 'Reasoned History' to the long wave pattern in world economic development. One can of course wonder why we bother to label this 'Reasoned History' as Social Economics. First and foremost it is basically to establish a bridge between the broad kind of economics asserted by Schumpeter and Freeman's approach, and in so doing highlight the connection between the two. The chapter will also offer some clues of an account of the history of ideas to this approach.

2.7.1 A Theory of 'Reasoned History'

In TGB (2001) a theoretical framework for a comprehensive approach to economic development is presented. The idea consists of viewing society as made up by five subsystems. The framework constitute these five subsystems as the following (Freeman and Louçã 2001:125-126):

i) *The History of Science* is the history of those institutions and subsystems of society that are primarily concerned with the advancement of knowledge about the natural world and the ideas of those individuals (whether working in specialised institutions or not) whose activities is directed towards this objective.

ii) *The History of Technology* is the history of the artefacts and techniques and the activities of those individuals, groups, institutions, and subsystems of society that are primarily concerned with their design, development, and improvement, and with the recording and dissemination of the knowledge used for these activities.

iii) *Economic History* is the history of those institutions and subsystems of society that are primarily concerned with the production, distribution, and consumption of goods and services and of those individuals and institutions concerned with the organisation of these activities.

iv) *Political History* is the history of those individuals, institutions, and subsystems of society that are primarily concerned with the governance (legal and political regulation by central, local, or international authorities) of society, including its military affairs.

v) *Cultural History* is the history of those ideas, values, artistic creations, traditions, religions, and customs that influence the behavioural norms of society and those individuals and institutions that promote them.

A theory of the history of economic growth and development should also, according to Freeman (2001), satisfy four main criteria: First it should provide a plausible explanation of stylised facts which summarise the main features of the growth of the world economy. Second, it should do this for the three main categories identified by Abramovitz (1986): 'forging ahead', 'catching up' and 'falling behind'. Third, it should identify the major recurrent phenomena in each category to pave the way for new generalisations, which should be constantly tested against new historical evidence. Fourth, and last, it should provide a framework analysing and reconciling the findings emerging from the various disciplines of history as described above. These five subsystems are chosen because they all have, to a varying degree, some *semi-autonomous* and significant influence on the process of economic

growth, a process in which "complexity and structural change can be explained only as historical developments, as co-evolutionary processes" (Freeman and Louçã 2001:122).

It should be noted that these five different subsystems are in themselves selection environments, thus constituting parts of the different selection environments described earlier (natural, built, and institutional selection environments) (Freeman and Louçã 2001). They all share one selection environment however, namely the natural environment. This environment concerns all these subsystems in the sense that they cannot escape it, i.e. no winnings or new combinations in technology, science, politics, economy, or culture will be sufficient to abolish the constraints the natural environment impose on society and the species sharing our planet. The other two categories of selection environments (built and institutional) are socially constructed, i.e. human made, and therefore also imposes radically different sequences of punishment and reward than the natural environment. As such one can consider these subsystems as subordinated the three main categories (natural, built, and institutional) of selection environments presented earlier, and also as a refined categorisation of selection environments affecting economic growth and social change.

The role and importance of history in analysing economic phenomena Freeman undoubtedly inherited from Schumpeter. For Schumpeter, history was the most important tool in economic analysis (brackets added):

> ...if, starting my work in economics afresh, I were told that I could study only one of the three (economic history, statistics, and economic theory) but could have my choice, it would be economic history I should choose. (1954:12)

Schumpeter justifies this stance on three grounds. First of all, he claims that no one can understand the economic phenomena of any time without an adequate understanding of historical facts (cf. *1.3.1*). Further, such a historical report cannot be exclusively economic in nature but must also contain or reflect the institutional facts that are not purely economic. Finally Schumpeter believed that errors in economics are most often a result of lack of experience in historical understanding and sense, not shortcomings in other economic tools or equipments (such as theory or statistics). It has been stressed in this thesis that innovations are results of social processes entailing qualitative change (*2.2.3 The Role of Selection Environments*), which in its essence and nature is historical, and can thus only be understood within a realistic historical framework. The focus on qualitative change also dictates a

realistic historical stance to economic phenomena, as in contrast to hypothetical deductive models widely applied in orthodox economics. And this importance of history in economic analysis is explicitly stated in Freeman's most recent framework (emphasis added):

> …economics is about the *real* evolution of complex societies. Assuming a *realistic* stance…a coherent research programme must be defined in our science (economics) by the *historical nature* of its subject matter. (Freeman and Louçã 2001:371)

This is not to say that Freeman neglected the role of history in his earlier research. On the contrary, this is in many ways a culmination of his early research and thus a realisation of a rationalised version of his early conceptions. The crucial factor is here to connect this Theory of 'Reasoned History' to the conception of techno-economic paradigms and the long wave pattern in world economic development. And this is exactly what Freeman does in the second part of this book. The first part, however, is concerned with presenting a thorough exposition of the foundation on the history of ideas and theoretical and methodological basis for the construction of the 'Reasoned History' framework, but mainly in the light of Schumpeter. However interesting the first part of the book may be, it will be devoted scarce attention. One could of course argue that the history of ideas would be of importance in revealing Freeman's research programme. Therefore some of this scarce attention we allocate to the history of ideas of the five subsystems, but will for the time being leave Schumpeter out of the equation. This is a sort of way to show what other scholars Freeman may have be influenced by, so we do not make the mistake and attribute all of Freeman's intellectual debt to Schumpeter. We shall assess these five subsystems in light of what possible earlier conceptions they may emerge from and what these subsystems contain.

The History of Science and Technology

The first tendency towards a system approach is developed in EII. Here the R&D system, with close connections to science and technology, not only appears, but is also attributed a crucial role in the theory of firms and industries. An interesting parallel could be drawn to Bernal's "The Social Function of Science" (Bernal 1939) where he constructed a system of technology much similar to that which Freeman portrays in EII. Hence, the subsystems containing *the history of science* and *the history of technology* have traces back to Bernal's theories. Bernal's conception of such systems was one of the first trying to assess science and technology as a clearly defined subsystem of society, further trying to measure it by identifying its boundaries. In "The Economics of Hope" (1992:5) Freeman also point to the fact that Bernal went beyond

the role of science and technology assessed by e.g. Marx and Schumpeter (who deduced his innovation driven approach partly from Marx). This wider and more important role of the science and technology system is also evident in Freeman's work. Bernal was also one of the first to establish science policy and technology policy as crucial aspects of politics and government intervention, an aspect Freeman devoted much time and effort in advocating.

The selection environment made up by *the history of science* is in essence concerned with understanding the development of science as a process not only consisting of 'internal' selection mechanisms (i.e. the criteria and methods in the scientific community itself) in science, such as in the Lakatos tradition (see e.g. Lakatos (1968, 1970)), but as a process of 'internal' and 'external' pressures such as the influence of the economy and politics (Freeman and Louçã 2001:127). Further, *the history of technology* studies the evolution of technology and technological artefacts (tools, processes, machinery, etc.) Thus this selection environment is essentially "the technological environment, the criteria of technical efficiency and reliability and of compatibility with existing or future conceivable technology systems" (Freeman and Louçã 2001:127)

Economic and Political History

When constructing a subsystem containing *economic history* and *political history* a relatively obvious connection to Keynes can be seen. Keynes made the crucial distinction between the economic and the political system in his "General Theory of Employment, Interest and Money" (1936). He considered the two systems as not being totally and fully interconnected and dependant, but rather as *semi-autonomous*, and connected and dependent only in certain fields within each system. This semi-autonomy is important in the sense that it dictates a relationship between the systems, but in the same time it does not fully integrate nor subordinate one system to the other. This quality of semi-autonomy is also transferred to the whole complex of subsystems presented above. Neither one of these five subsystems is fully integrated or subordinated to another, but function in its own right and in connection and symbiosis (whether 'out-of-sync' or in synchronisation, cf. structural crisis of adjustment) with parts of every other of the subsystems.

Economic history as a selection environment is primarily concerned with explaining economic change in connection to the interdependencies and evolutionary development in science and technology. Also, changes in statistical measures of economic history, i.e. capital

accumulation, growth of the labour force, productivity growth and GDP (GERD), is also believed to operate in close interdependency, or in a reciprocal relation, to technological history. The account of economic change must therefore be assessed in light of the scientific and technological selection environments. Such economic changes, given that they are pervasive enough, will often have influences on other parts of society, such as the political and legal organisation. Thus, *political history* must be concerned with the conditions imposed on technology and economy by the political and institutional system, and how the coordination between these different subsystems foster or retard the evolution of emerging techno-economic paradigms.

Cultural History

As we know the social changes concomitant from technical change and paradigm shifts is a necessary consequence of structural adjustment in Freeman's approach. The subsystem of *cultural history* is important when analysing theses social changes. These social changes are especially stressed in Freeman's works with Carlota Perez (e.g. the 1988 book section.). An early conception on the role of cultural history in influencing society and economy, perhaps also motivating such a focus in Freeman's approach, is Weber and Thawney's seminal assessment on the role of Christianity and industrialist society, namely "Protestant Ethics and the Spirit of Capitalism" (1958). This cultural history would also display itself in the institutional selection environment through those institutions and norms affecting the possibilities of acceptance of innovations.

As the qualitative changes in science, technology, and economy are not only subject to norms and ethics in the political subsystem, the *cultural history* is of importance in explaining emerging paradigms. As noted above such factors as religion can have vast effects on the development of these other subsystems and also on the limitations and possibilities of new technologies. As we know, the realm of scientifically conceivable is wider than the realm of the technically feasible, which in turn is far wider than the economically profitable, which in turn is wider than the socially acceptable. Namely in socially acceptable lies the argument of the cultural history.

As presented in the paragraph on the history of politics and economy, the semi-autonomy and independence between the five subsystems have been stressed. However, one would expect some interdependency (though not total), and some congruence between these systems. As a

matter of fact, the degree of congruence is vital to the success of these systems to provide insight in the processes of 'forging ahead', 'catching up', and 'falling behind' in economic growth (brackets added):

> Positive congruence and interaction between them (the five subsystems) provides the most fertile soil for growth, while lack of congruence may prevent growth altogether, or slow it down. (Freeman and Louçã 2001:124).

Therefore these five subsystems of society should be considered as contributors to economic growth and development, and as categorical, or classificatory for recurrent phenomena inherent in this process of social evolution. They are constructed on the basis of the fact that: "The problem with history is the almost infinite multitude of events" (Freeman and Louçã 2001:123), and therefore it requires such a simplifying and classificatory framework in order to classify, describe, and analyse these events.

2.7.2 'Reasoned History' and the Long Wave Pattern; Connecting the Dots

As noted in the introduction of this chapter the crucial operation is here to connect the Theory of 'Reasoned History' to the long wave pattern in world economic growth and development, and ultimately to the framework of successive techno-economic paradigms resembling this wave-like pattern. The second part of TGB is, as noted, concerned with applying the Theory of 'Reasoned History' in order to justify and confirm the previously suggested working mechanisms and implications of innovations, system- and paradigm change, and the concomitant social, structural, and institutional adjustments. This requires, as Freeman and Louçã (2001:148) point out, two things. First they need to assemble and analyse the empirical and historical data for each periods identified as a long wave. This is done to verify whether the evidence support or refute the above propositions (i.e. the preceding framework in Part Two). This operation will include both quantitative and qualitative analysis on the identified levels of analysis, namely the firm/industry level, national level, and international level, as well as on the technological level (i.e. for each radical technology believed to drive the contemporary upswing). Second, it will require the development of an 'appreciative' historical description. The notion of 'appreciative' lies in the argument of presenting stylised facts for generalisations of empirical recurrent phenomena in each of the so-called Kondratieff waves. As such this 'appreciative' theorising run along the lines proposed by Nelson and Winter (1982), who suggest two levels of theorisng; the formal theorising and

'appreciative' theorising. The former is more connected to logic and mathematics, the latter more connected to empirical work. This 'appreciative' theorising is done in order to identify and take account of the unique characteristics and idiosyncrasies of each wave, or paradigm, and further to demonstrate how each new constellation of radical innovations and technologies was developed, facilitated and diffused by the technological, scientific, economic, political, and cultural environment, i.e. the five subsystems of society constituting the Theory of 'Reasoned History'. This is a way of identifying and determining the influence and interdependency of the different selection environments contained in the five subsystems.

The crucial connection between the Theory of 'Reasoned History' and the notion of techno-economic paradigms lies in the analysis of the congruence between the five subsystems. Lack of congruence implies that these systems are out of synchronisation, i.e. the coordination between the subsystems, and also between the levels of analysis, is out of balance. Along the rationale of structural crisis of adjustments, with re-coordination and re-connecting of these systems in the phase of transition between paradigms, the congruence between the subsystems is argued to be strongest in phases of upswing and maturation of each paradigm constituting a long wave. This long wave pattern with relatively strong congruence will further make up phases *(ii)* to *(v)* in the evolutionary characteristics of techno-economic paradigms presented in *2.5.2 Techno-Economic Paradigms.*

The part of TGB dealing with this the relation between the Reasoned Theory approach and the historical accounts of the long wave pattern in general support the propositions and theories presented up to this point. It gives a credible and sensible description on the various processes of selection on each of the levels of analysis and in each of the five selection environments, identifying technologies and institutional, managerial, and political arrangements working in favour of the diffusion of new radical innovations and their clustering, or constellation, driving each long wave. Due to both space and relevance considerations we shall not go into further detail on these stylised facts, as it is done in the book and is therein readily available to anyone with interest for it (a condensed summary is presented in Table 2.6). Moreover, however interesting it may be, it does not serve an explicit purpose for us in our endeavour to reveal the evolution of the system approach and the Social Economics in Freeman's research programme. Rather we turn to a discussion trying to trace this evolution and compare Freeman's Social Economics to Schumpeter.

3 Part Three: Summarising, Comparing, and Some Reflections

This part will bring together the presentations and analyses from the preceding chapters and sections of Part Two. It will show how the work of Freeman, form the early start at NIESR and up to TGB, culminate in this last book and explicitly relate it to the research question presented in Part One, and offers as such a brief summary of chapters **2.3** – **2.7**. Further, a comparison is made between the system approaches developed, i.e. Social Economics, by Freeman and Schumpeter respectively. The chapter offers some methodical reflections as well as suggestions for further research, particularly in the area of extended assessments both on Freeman's work and the innovation studies field as a whole. Finally the chapter rounds up the thesis with some reflections on some more general aspects of Freeman's works.

3.1 Tracing the Evolution of the System Approach and Comparing Social Economics

This chapter is basically concerned with giving a plausible answer to the research question stated in Part One. The ultimate goal of this chapter is therefore to show how the system approach has evolved during Freeman's career, from the R&D system in firm and industry growth to the Theory of 'Reasoned History' on world economic development. As such the chapter starts with a brief summary of chapters **2.3 – 2.7**. This will lead into a comparison between Freeman's and Schumpeter's Social Economics.

3.1.1 Features of the System Evolution

First we look at the widening of scope throughout Freeman's works assessed here. This widening of scope is necessary to enable the interaction and merging of the systems developed. The first book, EII (1974) is concerned with innovation at the firm level and industrial dynamics and the conception of an R&D system. The second book, UTI (1982), is concerned with the more widespread effects of technical change (innovation) and its impact on social factors such as unemployment. It also takes the analysis to a new level, namely structural changes and the working mechanisms of technology systems. Further TPEP (1987) deals with the role of R&D, institutions, and government policies in economic performance at the national level, and subsequently performance in international trade and relates this to changes in techno-economic paradigms. At last, TGB (2001) deals with the complexity of the history of capitalist development from the industrial revolution in Britain in the mid 1700s

and up until the so-called information revolution in the 1970s. In these books the empirics are never in the foreground of Freeman's writings. Rather it forms and underlying structure on which he builds his analysis and addresses relatively universal problems. Based on the above one can consider Freeman's research career as culminating in this last book in the sense that he draws on the main contributions of his earlier research, improves, refines and ultimately synthesises it into a Theory of 'Reasoned History', a system approach to the evolution of capitalism. It is even tempting to claim that in this book his Social Economics, integrating other than strictly economic perspectives, comes to its full realisation. The below presentation is based on an understanding of Part Two as a way to interpret Freeman's theories.

It is also timely to recapitulate the chapters of Part Two concerning each of the systems in Freeman's work. It is clear, from the assessment in Part Two, that these systems should not be considered as instruments, but rather as conceptual frameworks for identifying and assessing determining factors of innovations and the changes they induce. Further we make use of the four features proposed in chapter **1.2.** We shall therefore examine each of the assumed connections in isolation and then try and synthesise the whole integration of these system.

First we consider the connection between the R&D system and the national system of innovation (**F1**). It is suggested that the scope of the R&D system is generally wider than that controlled by firms and organisations. It is believed to dictate the possibilities for firms and partly determine their conditions for innovation. We found in section *2.3.1* and *2.3.2* that this connection is valid. The crucial implication of this find is that national policies and priorities are essential for a countries industrial life. The shift from the military innovation system to the social innovation system presented in section *2.4.1* proves this point. From this shift Freeman deduced the idea of a national system of innovation and its normative principles; bringing back consumer sovereignty and setting goals and priorities for national R&D activities in order to promote a desirable path of development.

The next proposition concerns the connection between the emergence of technology systems and the national system of innovation (**F2**). It is suggested that given an effective enough national system of innovation, clusters of radical innovations and their concomitant managerial changes will from time to time lead to the establishment of new technology systems. We learned already in the taxonomy of innovations presented in section *2.1.1* that radical innovations accompanied by managerial and organisational changes constitute such

technology systems. However there is no mention of the national system of innovations in the taxonomy, although the role of diffusion is stressed. However, in section *2.5.1* we learned that in Freeman's framework the crucial diffusion process is facilitated partly by the national system of innovation. Even R&D initiatives capable of bringing out radical innovation with potential to establish new technology systems can be induced through the national system of innovation. As such it is not only in the process of diffusion but also in the establishment of new technology systems that national systems of innovations are of importance. This is by no means the same as to say that they are solely responsible for bringing about new technology systems. It is merely to prove the suggested connection between the establishment of new technology systems and national systems of innovations.

There is however one point concerning national systems of innovations which is not addressed in any of the four main features, namely its impact on a countries trade performance. This point is of crucial importance for a country that is 'catching up', and is addressed in section *2.4.2*. The propositions in this section suggest that the national system of innovation is vital in creating competitive advantages through technological, and thus productivity, advantages in trade.

The next suggestion to address is the development of technology systems with so radical potential that they transcend the borders of the industry and country of origin, ultimately constituting new techno-economic paradigms. It is suggested that this is dependent upon the potential and general applicability of the radical innovations constituting and the managerial and organisational changes accompanying them, and of course the environment for diffusion (also **F2**). This course of action seems to fit the assessment in chapter **2.5** rather well. As such this part of the working hypothesis could essentially be confirmed on the grounds of our findings in chapter **2.5**, but only with the inclusion of the fact that techno-economic paradigms often are clusters of technology systems. Further is suggested that successive changes in such techno-economic paradigms constitute the long wave pattern in world economic development (**F3**). This suggestion also seems to be confirmed in the last part of section *2.5.2* and in chapter **2.6**, and firmly tested towards alternative approaches as proposed by Mensch and Pasinetti.

Then, finally, there is the suggestion that Freeman's Theory of 'Reasoned History' is a merging of these above systems (**F4**). The integration and merging of all these systems (the

R&D system, national system of innovation, technology systems, techno-economic paradigms) are evident throughout the chapters **2.3 – 2.7**, where the interaction of their working mechanisms are presented. We can conclude that there has been a significant evolution of a system approach to analysing economic and social development throughout Freeman's research career, culminating in his Theory of 'Reasoned History' as a coherent, integrated, and general conceptual framework in which we can analyse and understand the making, and the wide implications, of the effects innovations bring about.

3.1.2 Freeman and Schumpeter; Comparing Social Economics

The idea of this comparison is to identify how these two kinds of Social Economics relate, as well as to establish some common features and contact surfaces between the two. For the outset of this comparison we make use of the Theory of 'Reasoned History' presented in the last chapter of Part Two, which we for the sake of convenience have termed Freeman's Social Economics, and the Social Economics of Schumpeter presented in the introduction identified as an economic science made up of the economic history, statistics, economic theory, and economic sociology and the results they produce. Thus we have two Social Economics each constituted by five and four elements respectively. This outset should constitute a comprehensible foundation for comparison. For the purpose of comparing, the two Social Economics are recapitulated in an illustrative juxtaposition:

Freeman's Social Economics:	**Schumpeter's Social Economics:**
The History of Science	*Economic History*
The History of Technology	*Statistics*
Economic History	*Economic Theory*
Political History	*Economic Sociology*
Cultural History	

The obvious difference which strikes us first is that Freeman's Social Economics is generally concerned with the role of history whereas Schumpeter's Social Economics defines history as a single and autonomous category, or rather a tool in economic analysis, namely economic history. Further, the elements in Freeman's approach are less of a toolbox, i.e. the five subsystems are not analytical tools per se. Rather they are subsystems of the social reality in which economic events occur, and regarded as having significant and semi-autonomous

impacts on the process of economic growth and thus also social change. In this sense the whole Social Economics of Freeman in many ways correspond to the conception of economic history and economic sociology in Schumpeter's framework, which therein are closely related.

However, to understand the significance of the impacts of these subsystems on economic activity we need to assess them in light of the analytical tools of statistics, theory and history cf. 'appreciative' theorising. A comprehensive combination of economic history, economic theory, statistics, and economic sociology is applied in the 'appreciative' theorising portrayed in the last section of Part Two. This approach requires an analysis of both quantitative and qualitative measurers and real historical accounts for each of the five subsystems. The application of economic theory (as defined by Schumpeter) in this approach will offer help in the labelling and terming of certain characteristics and evolutionary features, supporting a stylised facts representation. As such one can consider the Social Economics of Schumpeter to be represented in each of the five subsystems as means of method and theory. This does not undermine the approach developed by Schumpeter, but shows how the two approaches in many ways are alike, and how the categories from Schumpeter's Social Economics can be constructively fitted into each subsystem of 'Reasoned History', as well as how the two Social Economics are very much alike, depending on the level of analysis.

However, a point worth taking notice of is that Schumpeter never dictated semi-autonomy of his categories making up his framework of economic analysis, i.e. his Social Economics. Rather he conceived these four categories of analytical tools as parts of the same system and in many ways they even complement each other. This is especially true for the case of economic history and economic sociology.

In conclusion of this section it can be interesting to identify some differences between these two Social Economics as well. First of all the role of diffusion of innovation is much more emphasised in Freeman' Social Economics, than in Schumpeter's. This is portrayed through the emphasis Freeman puts on the role of selection environments and their influence on the possibilities and limits in diffusing innovations. Further, the role of the national system of innovation and active public policy within this system supports this claim. Second, where Schumpeter stressed the role of the entrepreneur in bringing out innovations, Freeman stresses the role of changes in management systems that accompanied each technological revolution

(Freeman and Louçã, 2001:149-150). This comes to the fore in the focus of managerial and organisational innovations presented in the section on techno-economic paradigms, as well as in the awareness of the massive institutional and social changes concomitant of technical innovation. The main task of these institutional and social adjustments is to match management and institutions to new radical technologies and the emerging techno-economic paradigm. As such, these managerial changes play an important role in the pervasiveness of any radical technology, or constellation of radical technologies, capable of constituting new techno-economic paradigms. The systemic linkages and interactions from micro, through meso, to macro in Freeman's framework offers in many ways a more thorough presentation, and thereby also a more trustworthy explanation, of economic development.

3.2 Some Methodical Reflections and Thoughts on Further Research

The intention of this chapter is, as the heading implies, to illuminate some alternative criteria, or rather approaches, to assess a research programme. One reason to do this is to show how and why the methodical approach applied in the thesis suits best the research question stated. Another reason is to show how other approaches could be fruitful in application. The two proposed alternatives are in many ways fruitful approaches, but would not, if applied, have been fulfilling the task of presenting a plausible answer to our research question. The reasons for this are presented below. Although these approaches are somewhat out of fashion, they offer some interesting aspects in this context. This project also entails a great variety of questions and fields worthy of study, which have not been researched in detail here. Such questions and fields are pointed to in the end of this chapter.

3.2.1 Schumpeter's 'Vision' in Scientific Procedure

One alternative approach, and perhaps also the most natural to think of, is Schumpeter's idea of a 'vision' in scientific procedure. It could be argued that the systemic approach formalised in TGB is a result of a 'vision', or a "pre-analytic act", as Schumpeter puts it (1954:45). The notion of a 'vision' is adopted from Schumpeter's "History of Economic Analysis" (1954) and means in this sense the following: a 'vision' in scientific procedure is two different, although not independent, acts. First of all scientific workers have a 'vision', a pre-analytic cognitive act, or an "intuitive perception of novel aspects" (1954:45). As such we could expect all scientific workers to have a 'vision'. It is however difficult to identify unless these scientific workers formalise this 'vision', such as Schumpeter did in his programmatic critique

of other researchers when engaging in the Methodenstreit[14], and in his early formalisation of a 'vision' which he pursued so relentlessly throughout his life (Prendergast (2005) and Rostow (1991)). This pre-analytic act is followed by an analytical act consisting of two steps, which are different in essence, but, however, inseparable. The first step of this analytical act is the conceptualisation of the contents of the 'vision', i.e. the naming and labelling of the concepts (theorems and propositions) encompassed in the pre-analytic act. The next analytical step is the empirical research, the search and collection of facts and data to enrich and confirm the already perceived theorems and propositions. These two analytical steps are inseparable in the meaning that they each encourage additional efforts in the other. As such they both help rationalise the 'vision', making it more logical and reasonable and also less intuitive and extraordinary. The collection of data and fact induce a reforming and improving in theorems and propositions, which in turn encourage a new hunt for facts and data to substantiate and confirm the new, improved and reformed theorems and propositions. In this way the endless sequence of the analytical act helps shape new theories and understanding of phenomena, motivated by a 'vision', i.e. an intuitive perception of novel aspects. Especially the second part of this procedure, namely the forming of concepts and theorems, and gathering of facts, is quite evident in Freeman's research. The rationalising of theories on the grounds of new empirical evidence is obvious in the books presented throughout Part Two of this thesis (EII, UTI, TPEP, TGB). The notion of an R&D system was refined and formalised into a national system of innovation partly based on the early conception in EII and partly based on the empirical evidence from the case study of the Japanese economic performance in the post-war era. Further, the clusters of radical innovation proposed by Schumpeter, evolved into the technology systems developed in UTI, and finally techno-economic paradigms in the book section Freeman wrote with Carlota Perez, but also presented in TPEP in 1987. The problem, then, with this approach is the identification of a 'vision', a pre-analytic cognitive act. Such 'vision' is hard to find unless it is formally introduced. However, in Schumpeter's understanding of this 'vision', we should expect all scientific workers to have such a 'vision'. Therefore we would expect Freeman to have one as well. However, since it is not formally introduced in any way it is hard to identify, and would render an attempt to assess Freeman's research programme in light of a 'vision' an unfinished act, as we could only identify the second act of this scientific procedure. Freeman did not produce any programmatic texts, as

[14] The Methodenstreit was a controversy between the theorists and the historical school of economists in the late 1880s and 1890s arguing over which was best for understanding economics; application of natural laws and systems of equilibrium, or historical evolutionary analysis (von Mises, 1969).

Schumpeter did, nor did Freeman early on formulate any ‘vision’ as did Schumpeter, which could be interpreted as a formalisation of a ‘vision’.

3.2.2 Lakatos Methodologies and Schumpeterian ‘Vision’

Imre Lakatos, a Hungarian philosopher of science, and is perhaps best known for his attempts to resolve the perceived conflict between Popper’s falsificationism (1959) and the revolutionary paradigmatic structures of science as proposed by Kuhn (1970). He was primarily concerned with natural sciences and would perhaps not even consider economics as a science. The attack on the neo-classical programme of the American economist Milton Friedman, by Lakatos’ colleague Spiro Latsis (1972) calling Friedman’s programme ‘pseudoscience’ along the demarcation criteria Lakatos identified to define science, substantiates this concern. The argument was that the neo-classical program did not predict any testable novel facts, and could thus not be defined as science along the lines of the Lakatos criteria for the demarcation between science and pseudoscience. This is for us a concerning remark, as the neo-classical programme of Friedman is highly positivistic and hypothetical deductive, i.e. it lies within the methodology of natural sciences, and should thus be closer to qualify as science than a more inductive and qualitatively oriented programme, such as Freeman’s. However, in a pragmatic turn we see beyond this demarcation criteria, and consider the characteristics of a research programme as suggested by Lakatos (1978), without regards to what (strictly) defines science. Arguably, the Lakatos characteristics can be applied not only to what would be defined as pure science, but also on ‘pseudosciences’, such as economics and other social sciences (see e.g. Vasquez (1997) for an application of Lakatos criteria on the realist research programme in international relations studies). Thus, we may assess Freeman’s programme in light of the Lakatos characteristics of evolution in research programmes.

Even though Freeman in essence refutes the Lakatos tradition (cf. *2.7.1 A Theory of ‘Reasoned History’*) in the evolution of science, some Lakatos characteristics are to be found in his research programme, at least if we do not apply the demarcation criteria for what constitutes science. It could thus be interesting to trace these characteristics and briefly compare them to the rationale of the ‘vision’ and the conception of social sciences as is applied as a frame of reference in the assessment of Freeman’s research programme in Part Two of the thesis.

Lakatos indentifies four characteristics, or rather features, of the methodology of research programmes (Lakatos 1978). These four features are the nature of problem shifts, i.e. the focus of research efforts. This can be progressive or degenerating. In fact, if the problem shift is progressive, the whole of the research programme is conceived as progressive. Such a progressive research programme is characterised by e.g. a growing field, discovery of new testable novel aspects, progression in empirics, and development of new experimental techniques. A degenerating research programme on the other hand is a research programme which is not progressive in theory (not posing new conjectures and predictions) or empirics (if the excess of new empirics do not lead to the discovery of new facts). The progressive characteristics are relatively evident in Freeman's research programme, and even the whole neo-Schumpeterian tradition of which we should consider Freeman a part. This is evident in the continuing of widening the field in terms of topics to investigate, development of new techniques, namely 'appreciative' theorising and the evolution of the system approach of 'Reasoned History'(and micro-meso-macro coordination analysis see e.g. Dopfer et al. (2004) in neo-Schumpeterian economics).

Further a research programme has its own methodology defining its priorities of focal attention. Every research programme has, according to Lakatos (1978) a 'hard core', and what he terms the negative heuristics, forbids us to direct *modus tollens*, i.e. the classical logic of causal relation (if X then Y), to this hard core. As such the negative heuristics should be considered the un-negotiable 'truth' at the heart of the research programme. Hence "the negative heuristics specifies the hard core which is irrefutable by the methodological decisions of its proponents" (Lakatos 1978:50). This, for instance, could be the conception of innovation as the main driver of economic evolution in Freeman's approach. But if we cannot direct the *modus tollens* towards this 'hard core' of the programme, where do we then direct it? Lakatos suggests that one need to construct, or even invent, what he call a *protective belt*, around this 'hard core', consisting of auxiliary hypotheses towards which we can direct the *modus tollens*. Confronted with the logic of causal relations this protective belt must be re-adjusted or even replaced to defend the thus hardened core.

However, there also exist a *positive heuristic* in a research programme. This consists, in contrary to the negative, of "a partially articulated set of suggestions or hints on how to change, develop the 'refutable variants' of the research programme, how to modify,

sophisticate, the 'refutable' protective belt." (Lakatos 1978:50). The purpose of these positive heuristics is to help the researcher to navigate in the ocean of anomalies, or counterexamples. Thus the vital task of these positive heuristics is to act against anomalies and modify and re-adjust theories and propositions to this end. These positive heuristics are also conceived as more flexible than the negative, and can as such, if the programme enters a degenerating state, by a creative shift of orientation, push the programme back into a progressive state. These positive heuristics can be identified as the different systems evolving throughout Freeman's research career. The conception of an R&D system, a national system of innovations, technological systems and techno-economic paradigms, are not only a result of a 'vision' as asserted earlier, but also constitute the positive heuristics, the protective belt surrounding the core of innovations as the driving force of economic evolution, bearing the brunt of tests and anomalies.

Lakatos makes a remark on some requirements of judging a research programme to be successful or not:

> While 'theoretical progress' may be verified immediately, 'empirical progress' cannot, and in a research program we may be frustrated by a long series of 'refutations' before ingenious and lucky content-increasing auxiliary hypotheses turn a chain of defeats – *with hindsight* – into a resounding success story, either by revising some false 'facts' or by adding novel auxiliary hypotheses. We may then say that we must require that each step of a research programme be consequently content-increasing: that each step constitute a *consistently progressive theoretical problem shift*. All we need in addition to this is that at least every now and then the increase in content should be seen to be retrospectively corroborated: the programme as a whole should also display an *intermittently progressive empirical shift*. (Lakatos 1978:49)

This conception of the evolution of a research programme contains strong similarities with the analytical steps of the 'vision' held by Schumpeter. This is evident in the imperative of establishing a dialectical relation between the real historical data and the progressive theoretical field (what Schumpeter called the *rationalisation of the 'vision'* by gathering new empirical data and constantly confronting theorems and propositions with these new findings) and what Lakatos conceived as *consistently progressive theoretical problem shifts* corroborating with an *intermittently progressive empirical shift*. However, Schumpeter's 'vision' must also be seen in light of his conception of the evolution of social sciences, as an evolutionary field constantly confronted with new societal challenges entailing needs for new knowledge to overcome these challenges. As such the Schumpeterian 'vision' is influenced by

the political, cultural, economic and historic institutions and developments in society as a whole, and not only limited to the internal criteria in science itself, as is the Lakatos research programme tradition.

This brief and superficial comparison offers no thorough assessment of the two approaches to evolution in research programmes per se. However, it brings justification to the methodical approach applied in the thesis, as well as our understanding of the emergence of social sciences (cf. **1.1**). Thus the applied approach is more suiting in assessing Freeman's research programme on the basis of the initially perceived broad approach of his research and theories, contrary to treating his system approach confined to the realm of economic science itself (which would be the case had we applied the Lakatos methodology). As such we can draw parallels to how Freeman treats economic development as a part of a social superstructure, as underlying the social reality and working in relation to other constituent parts of it.

3.2.3 Suggestions for Further Research

We round up this chapter with some suggestions for further research in relation to the topic of this thesis. These suggestions include points from the thesis which for various reasons have been left unexplored or devoted scarce attention.

A study not constrained by the time and space considerations like this thesis could assess Freeman's research by applying a larger empirical base, i.e. include all of his publications, which also will offer an expansion of the scope of topics with which he deals. Such an assessment is done for Schumpeter's works in Sloth Andersen's "Schumpeter's Evolutionary Economics" (2009). This would offer a more thorough assessment of Freeman's works and could also give a more detailed account of the history of ideas and influences directing Freeman's research. This would undoubtedly paint a more holistic and detailed picture of his research career. And in relation to this, another aspect in assessing Freeman's research programme, and its underlying conceptions, could be to situate Freeman in the literature on economic history, broadening the approach applied in this thesis. Such an attempt could compare Freeman's conception of capitalism and the historical perspective in economics not only to Schumpeter, but also to other relevant scholars such as Max Weber, Karl Marx, and Fernand Braudel, who all have different but interesting conceptions of the nature of capitalism, which many are alike those of Freeman, but also substantially different.

It is also of interest to compare Freeman's system approach 'Reasoned History' to orthodox economics, and apply it as a holistic *systemic criticism* of the orthodox theory, offering a complete alternative to orthodox economics. Few such explicit attempts have been done, and criticism of orthodox theory by applying evolutionary economics is perhaps the nearest thing to a similar comparison, even though the majority of these attempts are concerned with comparing certain aspects of economic theory, such as economic growth, the theory of the firm, actor behaviour, technological change, and so on, as is done in e.g. Nelson and Winter (1974) and more recent in Dopfer (1994).

Further, it is suggested above that Freeman has had some influence over the evolution of the neo-Schumpeterian programme, and a study relating Freeman's contributions to this development could be of interest as we have learned that he has been a significant contributor to the development of Schumpeter's theories and ideas. In relation to this, and based on the assumption that the field of innovation studies is in a phase of gaining momentum, a similar assessment of other authors considered great contributors to the innovation studies field (economics of innovations, innovation policy, innovation management, organisational innovations, and so on) could offer some insight to the roots and crucial contributions to the field. Such an assessment could for instance use the table of works (ranked by number of citations in what is considered six major handbooks on the fields of innovation studies) assessed by Fagerberg and Sapprasert (2010).

It is argued in the introduction that innovation studies as a field is a relatively young research field (emerging in its modern form during the 1960s and 1970s), and in a phase just now gaining momentum and acceptance as an independent field of study (cf. **1.1**). The above suggested research topics, as well as the contributions of this thesis (in considering Freeman as a core contributor to the field) would help assess this evolving structure of research we call innovation studies. As it was for assessing Freeman's works, the time is arguably ripe to also assess the innovation studies field as such.

Epilogue

After assessing Freeman's works and analysing it in light of the research question, as is done in the previous chapters, some question are still left unanswered and some thoughts left unexplored. Perhaps some of the conclusions drawn from this work can help point out a direction on some further research in Schumpeter's spirit, in addition to those proposed above. As Freeman himself points out, Schumpeter preached that his work should be considered as an outset for further research and criticism:

> Schumpeter never liked the idea of 'disciples' and advised his readers to regard his work as only a first approximation which should not be a dogma but a set of ideas to be revised and amplified in the light of new evidence. (Freeman 1994:464)

Freeman, along with others, has indeed done exactly this by constantly exposing theories, propositions, and ideas to new empirical evidence and scrutiny. As such, one can consider Schumpeter's intellectual legacy as sustained in Freeman's works, both in the sense of him further elaborating Schumpeter's ideas, and especially in rationalising them into his own conception of a world of systems, substantiated by new empirical evidence, and not least in widening the area of study from innovation on firm level and the business cycle, to topics such as technical unemployment, international trade, public policy, and environmental issues. As Freeman states regarding this:

> The neo-Schumpeterians have criticised Schumpeter's work very much in the spirit of his own advice, i.e. on the basis of new empirical research evidence. They have also tackled topics which he almost completely neglected, such as underdevelopment, international trade and regional development. (Freeman 1994:464)

However, these new empirical evidences and the broadening of research topics imply another essential part of the progression in science. The further development, and refining and rationalisation of Schumpeter's (or anyone's) ideas are not only contingent upon new empirical evidence. By the rationale of the 'vision', as presented above, one can argue that progression in scientific work and theory is not confined only to extended empirical research, but also the development of concepts (theorems and propositions), terminology, and frames of interpretation and understanding. Along these lines it makes little sense to regard accumulation of information or data sufficient in itself to constitute evolution in science. Rather, a dialectical relationship between the access to new real historical and sociological data and a progressing theoretical foundation need to be established (cf. 'appreciative'

theorising). In such a relationship new evidence can help form new theories and rationalise already conceived and established theorems and propositions. This dialectical relation is evident in Freeman's research. The conception of the national system of innovation, techno-economic paradigms and technical unemployment are products of such efforts of testing existing theories on the basis of new real evidence (as opposed to simulation models and computerised constructed data), as Project Sappho and the case of Japan, ultimately refining and refuting old concepts and theories and formulating new ones. This understanding and evolution of theory was crucial to Schumpeter. And as he claimed, before we can analyse real historical and sociological data, we need "to learn to think theoretically, to develop a sense for scientific abstractions". As matter of fact, it is actually after "we have become practised in theory" that our "contemplation of social reality teach us something" ((J. A. Schumpeter 1910/2003:60-61) cited in (Sloth Andersen 2009:330)).

There is however, no reason for those studying economic development and change not to continue this tradition and follow in Freeman's footsteps as he followed in Schumpeter's. On the contrary it is of crucial importance to the further development of broadening and exploring the knowledge base and even the entire field as such.

The role of knowledge and its application, i.e. what we have defined as innovation, have been put to the centre of economic and social change in the framework we have assessed and analysed. The history of these changes have been limited to the age of capitalism, i.e. from the first industrial revolution in the mid 1700s and up until today, and have not been applied on earlier economic and social systems and other economic epochs. What could then be more suiting in finishing this project than to end with some of Freeman's reflections on the role of knowledge in earlier societies: "Every human economy has been a 'knowledge economy' and not only the contemporary one, which we, in our arrogance, proclaim today" (2001:132). The major implication of this remark is that not only in modern economies under the reign of capitalism should innovation (applied knowledge) be considered a driving force of evolution. There is nothing in this train of thought which should leave scholars researching innovation satisfied with constraining their analysis only to the age of capitalism. However, this point goes both ways. Why should we only analyse the past, when the greatest possibilities and challenges lie in our future? Where do innovations lead us, as they must be understood not only as a means of human progress, but also as a means of war and destruction, and even as means of human enslavement (cf. Marcuse or de Beauvoir)? Regarding this, the future of the

human species, Freeman states, along the lines of the introduction to EII and in conclusion of TGB, that he hopes this latter book (emphasis added):

> ...shows the various ways in which our theory of 'Reasoned History' differs from Schumpeter and from other earlier efforts to *explore the relationship between technical and social change*... I hope that the ideas developed therein...will explain to a small extent why *I remain fundamentally optimistic about the future of the human species*. (2008:239-240).

And further, as initially noted, on the influence of technical innovations: "We cannot escape its impact on our daily lives, and the moral, social and economic dilemmas with which it confronts us. We may curse it or bless it, but we cannot ignore it" (Freeman 1974:15). It seems, by the former citation that Freeman leans toward blessing it, as Adam Smith, as a liberating Promethean force, necessary and sufficient for the progress and future of human society.

Appendix

Who is Christopher Freeman? A Stylised Facts Biography

Christopher Freeman[15] is an English economist born in 1921. His main areas of research are technical change in economic theory, science and technology indicators, the diffusion of generic technologies and their future implications, structural change in the world economy, and the 'catching-up' efforts of East Asian and Latin American countries. He is by many considered a pioneer in the work on the measurement of scientific and technological activities, especially on the statistical measurement of R&D and innovation, and contributed substantially to constructing the first OECD manual (the Frascati Manual) for a standard of such measures. He is also credited for introducing the concept of National System of Innovation, along with B-Å Lundvall. As such he is considered of many as perhaps the most influential modern long wave theorist and researcher.

Freeman was educated as an economist at London School of Economics during the Second World War (from 1941-48), and conducted his war service in the 1st and 5th Battalions of the Manchester regiment. After the war he undertook teaching as well as working as a researcher tackling the problems of international market forecasting (1948-1959). In 1959 he joined the National Institute for Economic and Social Research (NIESR) in London, where he worked on the role of innovation in knowledge intensive industries such as chemicals and electronic components. He left NIESR for the University of Sussex to serve as first director of the new established Science Policy Research Unit (SPRU). He served as director of SPRU and RM Phillips Professor of Science Policy until 1982. From 1986 he has been Emeritus Professor at SPRU. After 1982 and onwards he has had positions as Professorial Fellow at the University of Limburg, Visiting Professor at the University of Aalborg and served on expert committees for e.g. IBM and the European Commission.

Further he has mentored several generations of economists and social scientists working on technical change, innovation and the knowledge society. Among them are, Keith Pavitt, Luc Soete, Carlota Perez, Mary Kaldor, B-Å Lundvall, Daniele Archibugi, and Giovanni Dosi, every one of which is familiar names within the innovation studies field. Freeman now lives his old days in peace and quiet in Brighton.

[15] The information on Freeman was found at his webpage: freemanchris.org (04.24.10)

Honours and Awards

Honorary Ph.D., University Linkoping
Honorary Doctorate, University Sussex
Fellow, London School of Economics
Honorary Doctorate, University Middlesex
Honorary Doctorate of Laws, Birmingham
Honorary Doctorate, University Brighton

Bernal Prize, 1987
Schumpeter Prize, 1988
Prix International du Futuroscope, 1993
World Technology Network Award for Policy, 2001

A Briefly Commented List of Freeman's Selected Works

The texts are presented chronologically and sorted according to if it is a book/book section or an article/paper. The purpose of this is to place the texts chosen, both in time and in relation to each other according to topic. The selection of works presented here are in many ways the greatest contributors to the empirical basis of this thesis. Most of them are also the most cited works of Freeman, with some exceptions. A Google Scholar citation count (GSCC) is also included for each publication.

Books and Book Sections

The Economics of Industrial Innovation (1974) 1. Edition. (EII) This book have been published in three editions (1982 and 1997), each with extensive additions in theory and empirical research. However, the first edition serves as outset for this thesis as it contains the early ideas of the concept of innovation and change crucial to Freeman's conception of the intrinsic processes of social evolution, and in this capacity portrays his 'vision' in an early phase. It is concerned with identifying an R&D system and the making of industrial innovation, as well as stressing the importance of such advances in the process of economic growth. The empirical basis for the book is in large the findings from the Sappho Project. *GSCC: 4178*

Unemployment and Technical Innovation; a study of long waves and economic development (1982), with John Clark and Luc Soete. (UTI) In this book the authors connect the phenomena of technical change, unemployment and long wave development. It argues that with the introduction of new technical innovation one will witness a massive labour displacement. These structural changes are fitted into the wave-like pattern of economic development and

arguments of unemployment being necessary as a result of structural crisis and adjustment in the transition between a trough and a peak in the development pattern are presented. It incorporates the R&D system findings from the former book and connects it to the changes in technology and economic systems and the concomitant structural changes. It even provides some suggestions for policy to mitigate the massive labour displacements during such system transformations. *GSCC: 756*

Technology Policy and Economic Performance; lessons from Japan (1987). (TPEP) This book is in essence concerned with the economic and competitive performance of the Japanese economy in the post-WWII decades. It links the contemporary success of Japan to the similar cases of Britain and Germany during the 1700 and 1800s. The main focus is the ability of Japan to import and imitate foreign technology, improving it, scaling it up and putting it to commercial use with more success than its originators (Germany, UK, USA). The emphasis is put on what Freeman terms Japan's national system of innovation, and its success in facilitating and exploiting technical and managerial innovations in order to 'catch up' in world economic development. It also provides some suggestion for national policies, such as to be as successful as Japan in this 'catching up' process. *GSCC: 2689*

Structural Crisis of Adjustment, Business Cycles and Investment Behaviour (1988), with Carlota Perez. Book section (pp. 38-66) in Dosi, Technical change and economic theory (1988). This is a Book Section in an anthology, written with Carlota Perez. It provides a useful and schematic overview of innovations and their implications, as well as connecting them to changes in technology systems and techno-economic paradigms. This taxonomy of innovations was introduced in detail in a section *2.1.1 A Taxonomy of Innovations. GSCC: 1544*

The Economics of Hope; essays on technical change, economic growth and the environment (1992). Is a collection of published and unpublished essays or papers. It is carefully edited so as to provide a background for Freeman's approach and the development of his 'vision', as well as discussing interesting implications related to social policies and the environment. It is mainly concerned with the connection between technology and growth, and the possibilities of the future, offering a non-deterministic view of technology for the future.
GSCC: 92

As Time Goes By; from the industrial revolution to the information revolution (2001), with Francisco Louçã (TGB). This must be acknowledged as the master piece of Freeman's work, the manifesto of his research career, expressing the culmination of the system approach. The first part of this book, written by Francisco Louçã, which in detail goes into the epistemological foundations of his approach. The second part of the book, written by Freeman presents a thorough analysis of economic development form the industrial revolution up until today, with solid historical, social, political, economic and statistical analysis. It portrays the complexity in Freeman's approach incorporating, in an all-encompassing manner, the interactions of the systems developed in earlier research. It should be considered a great contribution to the field of economics and economic history. *GSCC: 537*

Journal Articles and Papers

Technological Infrastructure and International Competitiveness (1982/2004) (TIIC). This paper was originally prepared for the OECD Ad-hoc group on Science, Technology and International Competitiveness working from 1980-83. However the paper did not get published at the time partly due to bureaucratic inertia in the OECD, and was re-discovered in September 2001 and brought to attention on Freeman's anniversary party, by Jan Fagerberg, and later introduced on a GLOBELICS conference in Rio de Janeiro in November 2003 by Lundvall, and finally published in 2004. It is one of the first modern conceptions of the 'national system of innovation', and draws the line back to Friedrich List's conception of national systems in political economy. It provides arguments of why national systems are of importance in economic performance and trade. It offers a critical review of what was in the 1980s new theories of international trade. It shows how technology can give absolute competitive advantages, and how technological leadership will reflect in institutions facilitating coupling, creating, comprehensive clustering and coping with technical progress, and finally how the traditional arguments, such as relative prices, comparative advantages and wages cannot explain competitiveness. It also shows how public investment and policy is crucial for successful economic development. *GSCC: 97*

Economics of Technical Change (1994). This is the first paper in a series of critical surveys on recent developments, to provide an assessment of alternative approaches and to suggest lines of future research on technical change in the Cambridge Journal of Economics. It assesses the

field (which Freeman terms neo-Schumpeterian economics) and its contradictions, relates it to its ideological foundations in e.g. Marx and Schumpeter, and shed light on the evolution of the innovation studies field. It is mainly concerned with the topics on which Freeman considers new empirical research to have been most influential, namely innovation on the firm level. It offers a thorough disposition on the influences and changes in direction on this research from Schumpeter up until the 1990s. *GSCC: 776*

The 'National Systems of Innovation' in Historical Perspective (1995). This paper is concerned with the importance of national systems of education, industrial relations, technical and scientific institutions, government policies, cultural traditions and several other national institutions, in successful economic development. The paper argues that despite the recent development of the 'borderless' in globalisation studies, the importance of regional and national systems of innovation still stands, on the grounds of the fundamental importance of e.g. national policies and education. *GSCC: 1093*

In addition to these publications listed above, Freeman has contributed with book sections and papers on a large scale. He has also edited several anthologies on similar topics of that above. These additional texts are however excluded from this list, as they are not regarded as core texts in the thesis. These omissions are a combination of both space as well as relevance considerations.

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